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# Flexible Spectrum Use and Laws of Physics

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Formerly:

V-Chair, ITU Radio Regulations Board, Geneva  
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V-Chair, CCIR SG1 on Spectrum Management & Monitoring  
Professor, Institute of Electrical Metrology, Wroclaw  
Editor-in-Chief, Global Communications, London  
Consultant, ITU, UN-OCHA, WB, etc...

# Flexible spectrum use

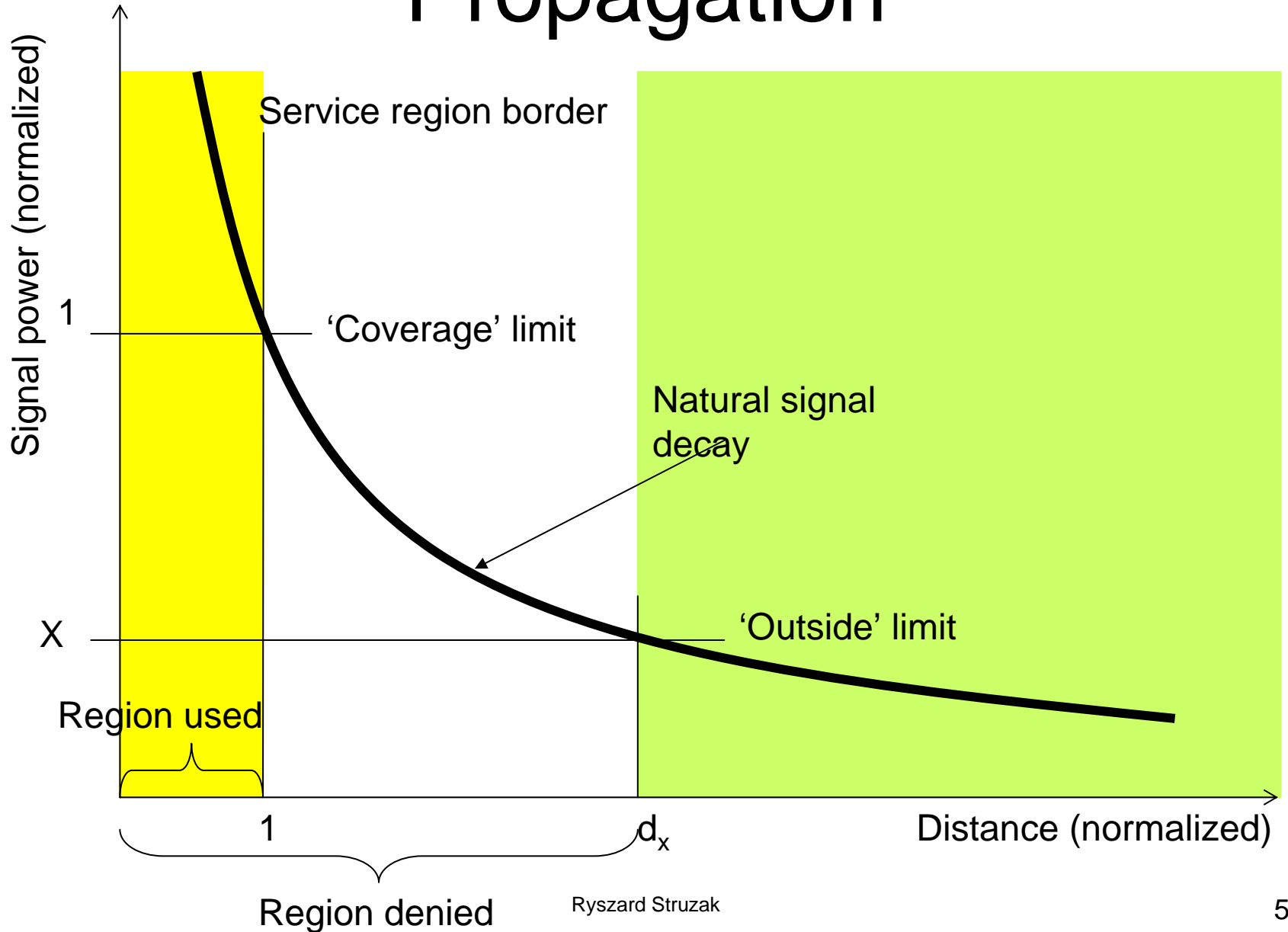
- traded, aggregated, divided and freely used for a wide range of user-selected services
  1. *Transmit within signal power restrictions inside your licensed electrospace region*
  2. *Keep your signals below 'X' outside that region"*

Source: Matheson RJ: Flexible Spectrum Use Rights. Tutorial. International Symposium on Advanced Radio Technologies (ISART) 2005

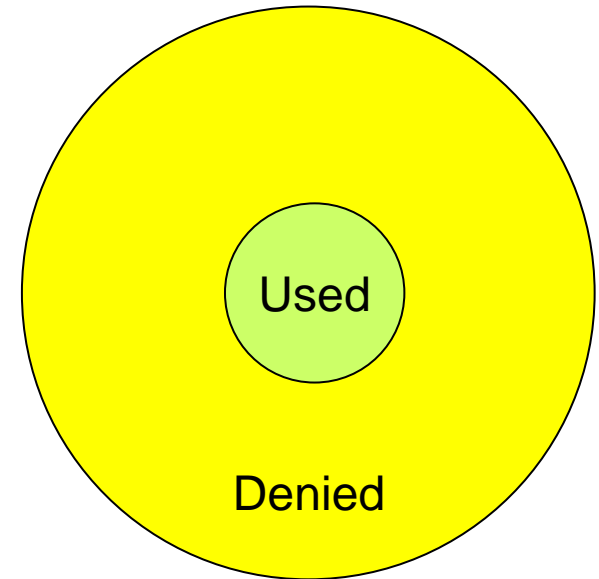
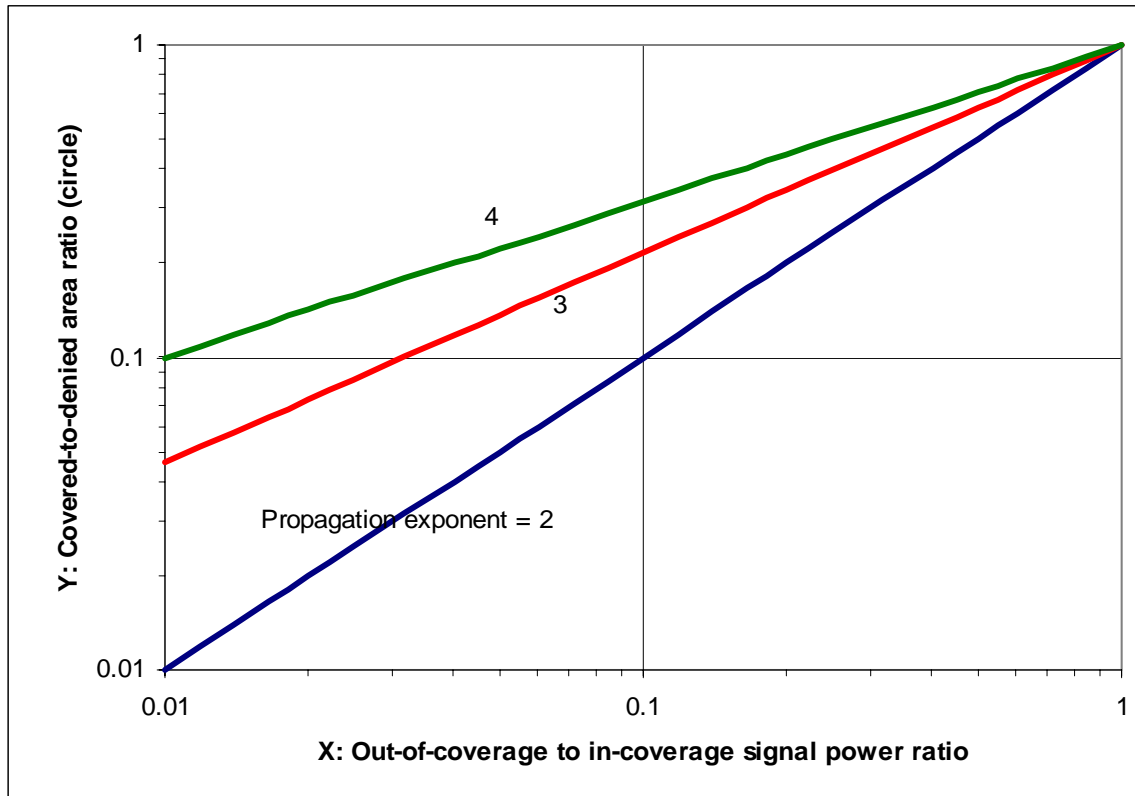
# Presentation aim

- Call the attention to constraints resulting from laws of physics
  1. Radio wave propagation
  2. Unwanted electromagnetic interactions

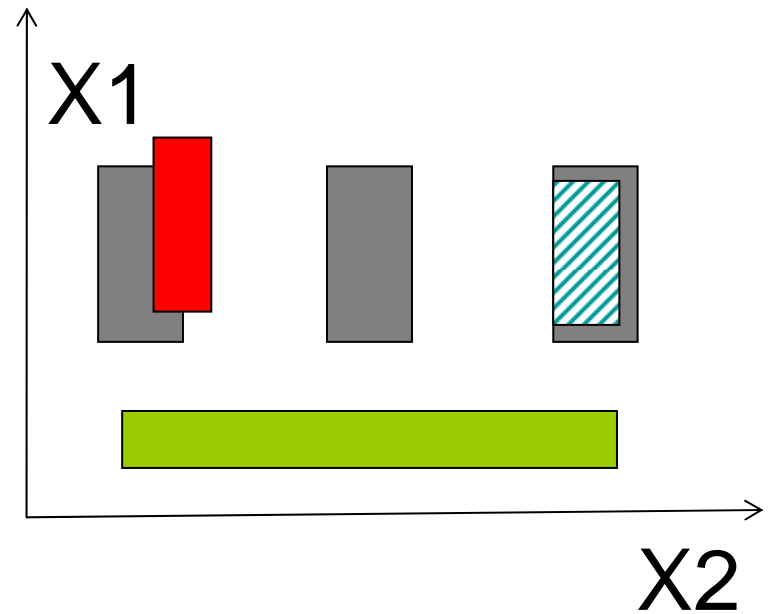
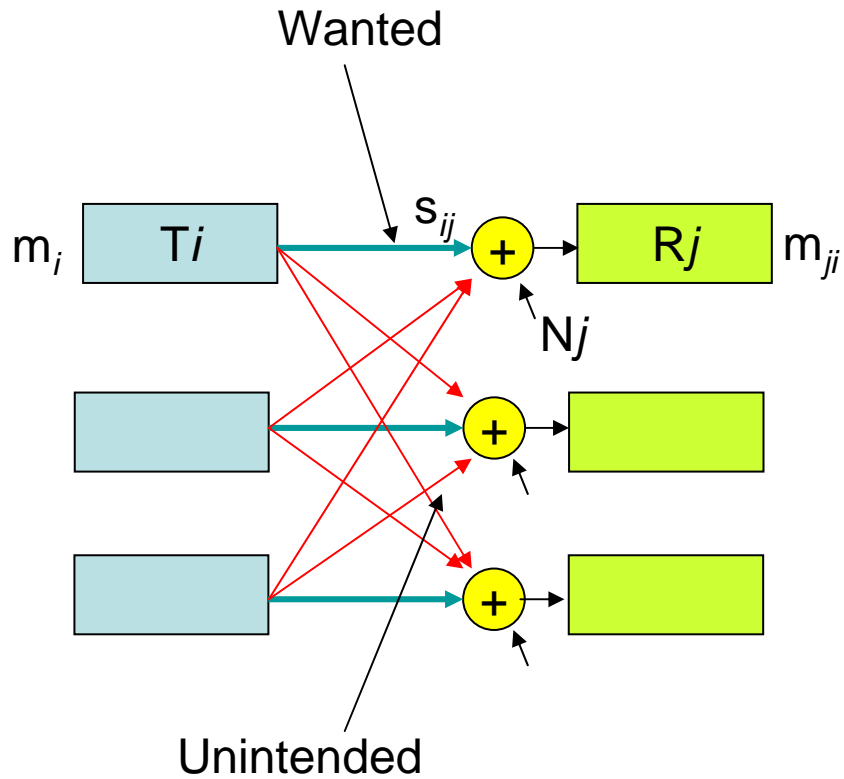
# Propagation



# Covered vs. denied areas

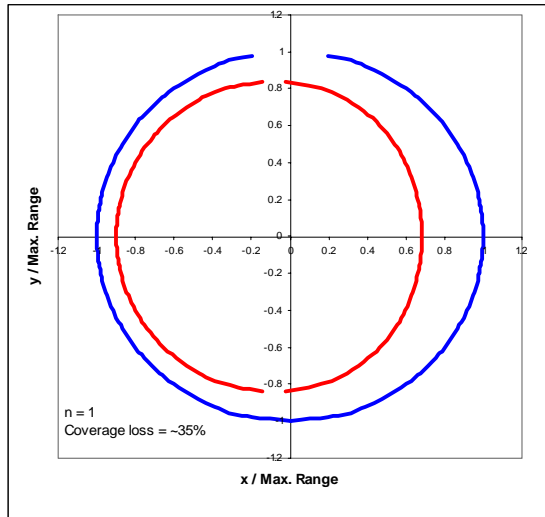


# Coexistence

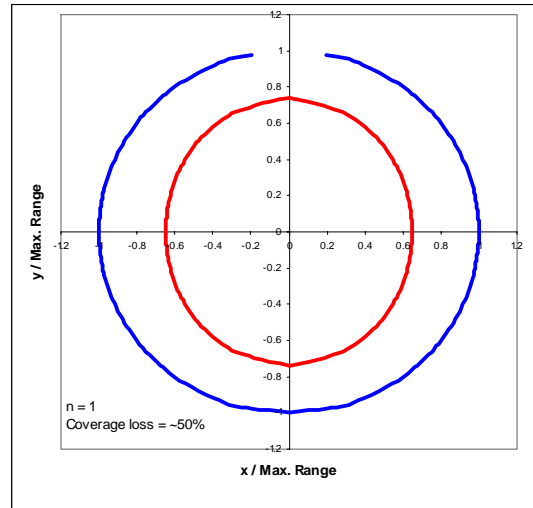
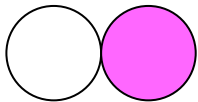


Struzak R: Evolution of Spectrum Management Concepts; Electromagnetic Compatibility 2006.  
 Proceedings of the Eighteen International Wroclaw Symposium on Electromagnetic Compatibility, June 28-30, 2006, pp. 368-373

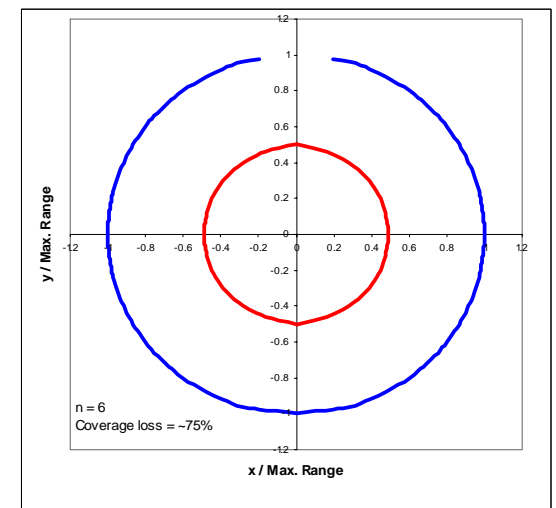
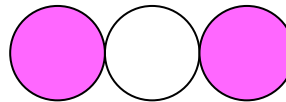
# Impact of unintended radiations



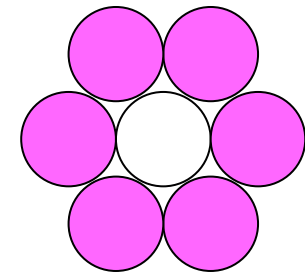
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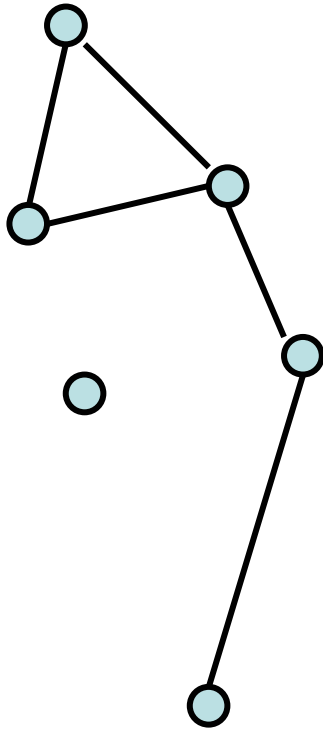
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# Open questions

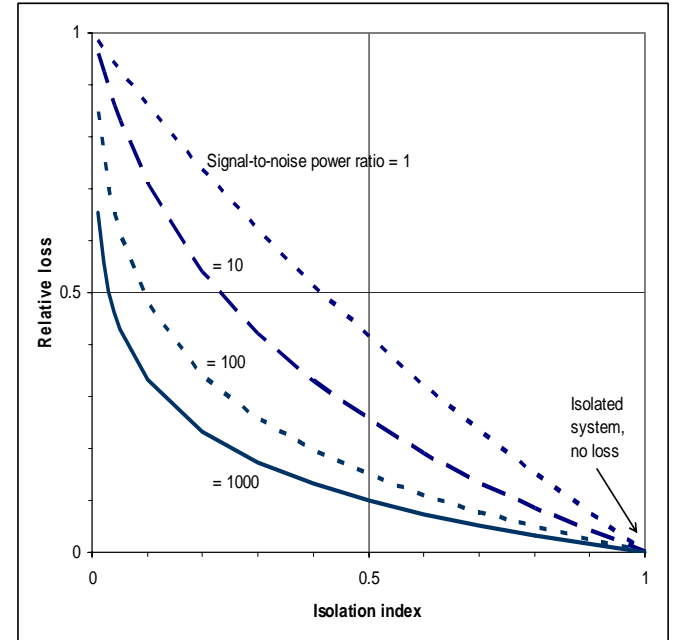
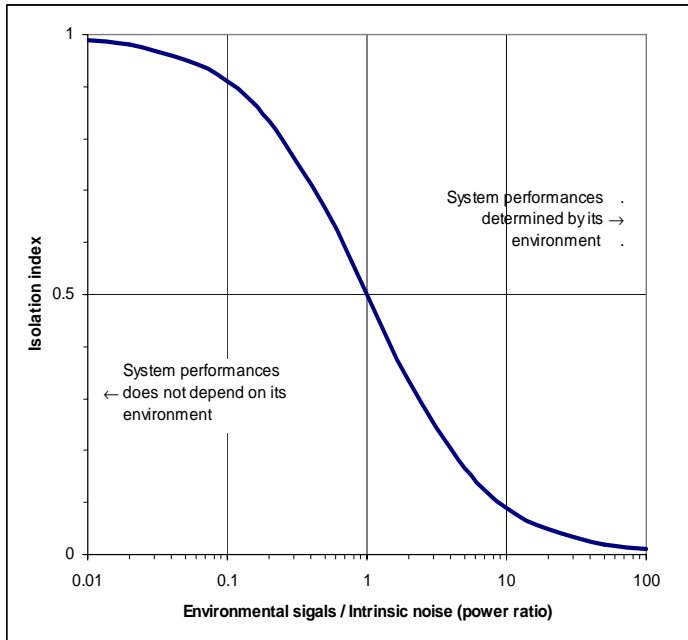
- The coverage decreases with each new transmitter added
- So does the income of the service provider
  - Should the income decrease be accepted?
  - Should a compensation be demanded for the loss?
  - Will this depreciate the market value of the business?
  - Will this influence the investment decisions?
  - Passive services?

# Unintended radiations



- Effects depend on
  - features of individual systems
    - can be controlled by flexible use rules of type '1' and '2'
  - their number and spatial deployment
    - **Cannot be controlled by flexible use rules of type '1' and '2'**

# Isolation coefficient



Struzak R: On Spectrum Congestion and Capacity of Radio Links; Annals of Operations Research 107, 2001 (2002), pp. 339-347

# Conclusions

- Except for sparse systems, the systems' features depend on unintended interactions with other systems
- Interacting systems behave as a network
- Technical & operational characteristics of co-existing systems (network components) must be harmonized/ coordinated

- Once coordinated, there is little flexibility, if any, in modifying operation of individual systems
- The rules of flexible spectrum use are insufficient in congested environments
- Additional rules are needed to ensure coexistence of radio systems

- Laws of physics are independent from spectrum property rights, management rules, protocols, technologies, etc.
- Flexibility in spectrum use/ management requires intelligent, cognitive, cooperative SDRs with dynamic access to spectrum resources, able to adapt automatically their operation to changing environment

Thank you for your attention