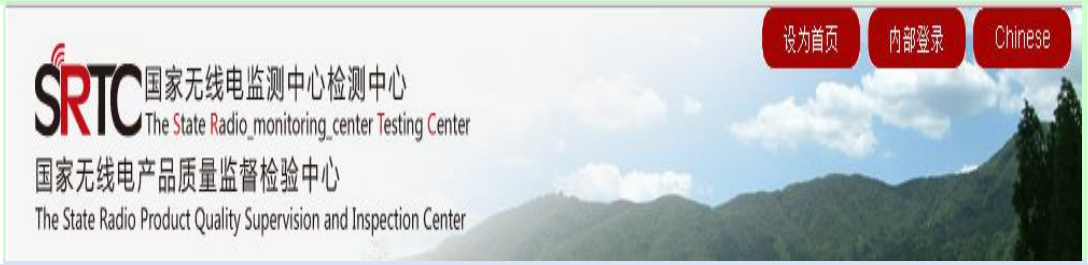

State Radio monitoring center Testing Center (SRTC) Beijing; 8 Jan.2016

and

Xihua University; Chengdu, Sichuan, China: 11 Jan. 2016

National Spectrum Control

Spectrum Management and Monitoring

Dr. Haim Mazar; Vice Chair ITU-R Study Group 5 (Terrestrial Services)

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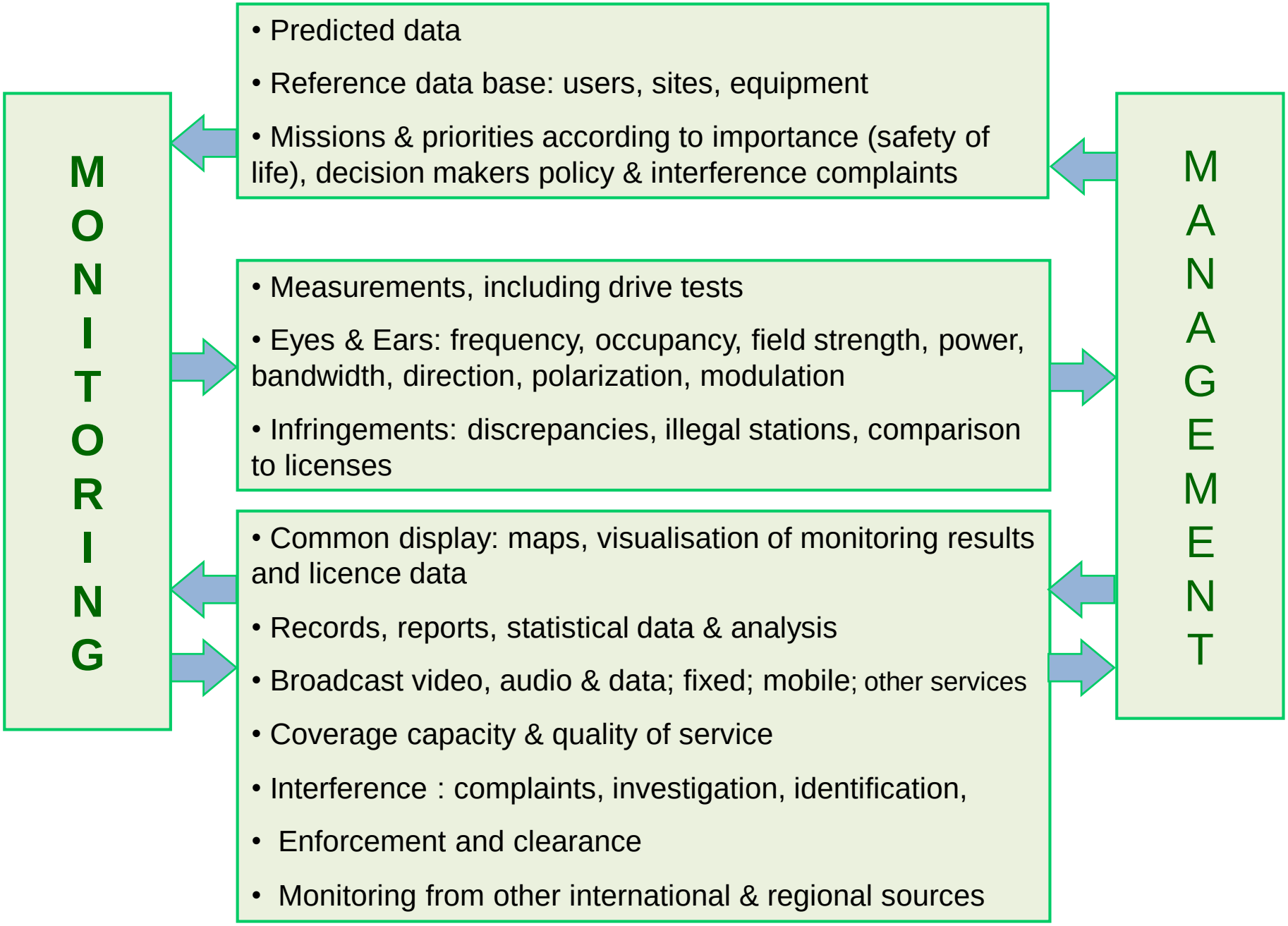
Sources of the presentation

- 44 years of RF experience at all radio communications services
- 30 years of RF Spectrum Licensing and Monitoring
- Development of two Computer Aided Techniques for National Spectrum Management
  - Spectrum Management 'Shraga'
  - Spectrum Management System 'Iris' and ICS Telecom
- Recommendation ITU-R SM.1370 Design guidelines for developing automated spectrum management systems
- ITU Spectrum Monitoring Handbook 2011
- ITU Computer-aided Techniques for Spectrum Management (CAT) 2015
- ITU Handbook on National Spectrum Management 2015

Interrelation of national spectrum management & monitoring functions



National Monitoring capabilites (1)

Derived from policy, coverage and propagation

China (Mr. Chang Ruoting, Dr. Ding Jiaxin and Mr. Wang Zhixin)

- HF Monitoring: SRMC responsibility; 9 stations: Beijing, Harbin, Shanghai, Fujian, Shenzhen, Chengdu, Yunnan, Shanxi and Urumqi; Beijing is ITU international monitoring station
- VHF/UHF Monitoring: provincial stations implement VHF/UHF monitoring, including listening, measuring and interference location.
- Space Monitoring: SRMC responsibility; in Beijing and Shenzhen

• France

- 46 (in 2013, 57 in 2006) monitoring stations, controlled from 7 regional offices
- 6 regional services (Aix- Marseille, Donges, Lyon, Nancy, Toulouse and Villejuif) operating 35 fixed V/UHF DFs & 11 fixed with movable directive antennas, connected to 7 centers. In addition 4 mobile DFs, 25 transportable stations, 24 laboratory vehicles & 1 vehicle for SHF to monitor the satellites and radar bands. To monitor HF a fixed ant. field of 34 hectares in *Centre de contrôle* ***international*** Rambouillet: 6 diamond high gain ant. for global control, 1 DF on a mobile laboratory vehicle & access to the Ministry of Defence network.
- ANFR may close the French remote controlled stations

National Monitoring capabilities (2)

- Germany (Mr. Ralf Trautmann)
  - About 85 fixed monitoring stations (manned ones, as well remote controlled ones with and without direction finders)
  - 99 measurement vehicles
- UK (Mr. Steve Ripley)
  - Ofcom's monitoring station: Baldock in Hertfordshire
  - 70 field cars
  - network of remotely accessible monitoring stations across the UK
- USA (Mr. James Higgins): approx. 110 monitoring site- including fixed, mobile and portable
  - 23 FCC offices include 1 fixed monitoring VHF/UHF, 2-4 mobile DF/monitoring vehicles at each office & transportable/portable sites.
  - FCC operates 14 fixed HF sites

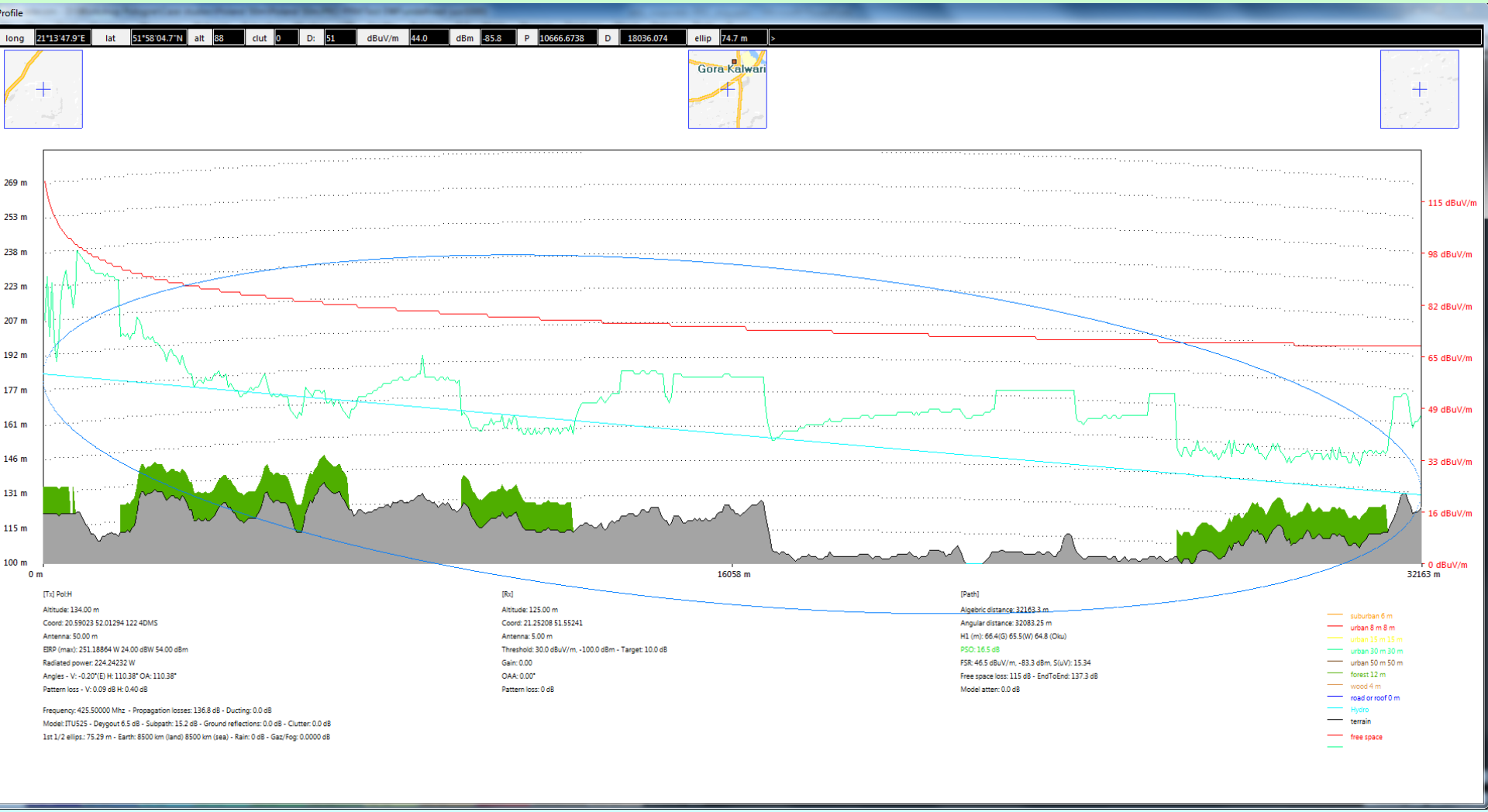
Items which need to be regulated

1. RF allocations to radio services; follow ITU Radio Regulations
2. Assignment of licence and RF to Tx Stations
3. Fee collection: RF License & annual fees
4. Equipment Type approval; EU R&TTE is liberal
5. Coordination with neighbour countries (no borders to the ElectroMagnetic waves)
6. Notifying ITU to the Master International Frequency Register (MIFR) e.g. http://www.itu.int/ITU-R/eBCD/ePub.aspx
7. External relations: toward ITU, International and Regional orgs see http://eprints.mdx.ac.uk/133/2/MazarAug08.pdf p. 179

Roles of the National Spectrum Management

1. Avoid and solve interference
2. Design long and short range RF spectrum
3. Support Engineering: propagation, coverage…
4. Coordinate with military wireless services
5. Advance new wireless technologies (such as cognitive radios; digital audio and video)
6. Coordinate with other Administrations
7. Advance new technologies & efficient import
8. Serve your clients, the public: be transparent
9. Reduce RF human hazards

ATDI ICS telecom – profile analysis window the basics of all engineering work



Roles of RF monitoring

- Ensuring operation of transmitters in conformity with national and international regulations and licence conditions
- Verification of proper technical and operational characteristics of authorized transmitters
- Detection and location of unauthorized transmitters and interference
- identification and resolution of interference problems
- Measuring spectrum occupancy
- Validation of propagation and sharing models

Analyses in multi-domains

uses data from Recommendation ITU-R SM.2039 Table 1

Level vs. Time	Level vs. Frequency	Frequency vs. Time	In- phase vs. Quadrature-phase	Space vs. Frequency
amplitude, pulse, eye-diagram	spectrum, occupancy, unwanted emissions, mask of emission, noise	frequency stability, RF offset, frequency hopping	constellation-diagram, EVM (Error Vector Magnitude), phase offset	multi-channel direction finding

Priorities in Licensing: derived from worldview and policy considerations

- national security
- emergency communications
- law enforcement
- safety-of-life, aviation, maritime
- space communications
- Scientific
- Social

How to manage the RF Spectrum (1)

1. Follow Regional Allocations and Assignments; try to ease circulation of equipment
2. Coordinate (bi-lateral and multi-lateral) with your neighbours
3. Even in China, don't invent specific allocations; with whom do you want to be identified? Follow its rules and standards

- Importance of standards: Qin dynasty 221-206 BC introduced standardization: uniform written language, currency, weights & measures (e.g., length of chariot axles)

QinShiHuang
Xi'an, Shaanxi province

How to manage the RF Spectrum (2)

1. Transparency; light touch (?); central-based or market-oriented? Auctions?
2. Try **not** to allocate to fixed transmitters and receivers (e.g. TV from air), if there is an alternative (cable or satellite)
3. Allocate RF spectrum with a vision towards implementing in many cases markets
4. Ensure the effective (reuse) and efficient (bits/hertz) use of the RF Spectrum
5. Decrease Interference by assigning: min power, min bandwidth, max frequency

Trends in Spectrum Management: decrease time scales & wireless innovation & entering new technologies

- WARC-1992 designated 1,885-2,025 MHz & 2,110-2,170 MHz for IMT-2000; in NTT DoCoMoJapan operated UMTS in 2001
- 2.6 GHz was allocated at WRC-2000; LTE systems at 3GPP band 3 UL 2,500 MHz–2,570 MHz and DL 2,620 MHz–2,690 MHz were launched end of 2010
- 790-862 MHz was agreed at WRC-2007. Vodafone launched its 800MHz LTE network in Germany in December 2010.
- 694-790 MHz (called the '700 MHz band'), in ITU Region 1, started at WRC-2012 & may come into force in 2015. Germany (June 15; over €1 billion) & France (Nov. 15, €2,8 billion) already auctioned the 700 MHz band

Trends in Spectrum Management: spectrum efficiency

- Despite spectrum scarcity, most spectrum is unused even in developed countries
- Only Cellular, FM and 2.4 GHz bands are densely occupied around the world
- Cognitive Radios & white space devices improve the spectral efficiency
- Advanced spectrum sharing licensing:
  - Licensed Shared Access (LSA) in Europe or
  - Dynamic Access to Spectrum (DAS) in America
- Spectrum Audit

Promoting New Technologies

- Australia decided in 2000 to license only digital technologies
- Defining what is harmful interference
- Ultra Wide Band (UWB)
- Soft Defined Radios (SDR), cognitive radio systems (CRS) and white space devices improve the spectral efficiency.
- MIMO and other adaptive antenna technologies can readily change the C/I
- Power Line Telecommunications advance broadband

Techniques to reduce interference

- Dynamic Frequency Selection (DFS)
- Spread Spectrum modulation
  - direct-sequence spread spectrum (DSSS)
  - frequency-hopping spread spectrum (FHSS)
- Detect And Avoid (DAA)
- Listen Before Talk (LBT)
- Transmitter Power Control (TPC)

Theories and Policies

1. So begins Leo Tolstoy's Anna Karenina : ‘All happy families are alike; each unhappy family is unhappy in its own way’
2. Between 2 points in planar geometry there is only one simple line, but indefinite curves
3. 'Great minds think alike' (Michaelian)
4. ‘Stand on the shoulders of giants‘ (also I. Newton)
5. 'Okham’s Razor': ‘if you have to choose between competing theories, choose the simplest theory- it is most likely to be true’

International, Regional & National RF Spectrum Management

The author

Geneva, October 2007
ITU Radio Assembly

Source: ITU / J.M. Ferré

Dr. Haim Mazar; Vice Chair ITU-R Study Group 5

Related author's publications & presentations

- Worldwide, Regional and National Unlicensed and Unprotected RF allocations, for Wireless Network Access (including Social Issues) ; ITU-T workshop all-star network access; Geneva, 2-4 June 2004
- *An Analysis of Regulatory Frameworks for Wireless Communications, Societal Concerns and Risk: the Case of Radio Frequency (RF) Allocation and Licensing* Boca Raton Florida: Dissertation.Com, 2009
- A Comparison Between European and North American Wireless Regulations, presentation at the 'Technical Symposium at ITU Telecom World 2011' www.itu.int/worl2011 on 27 October 2011; hyperlink to the slides presentation, 27 October 2011
- International, Regional and National RF Regulation and Standardization; presentation at "Ruppin Academic Center", 31 December 2013
- Academic_Course_Engineering_2015.pdf; Academic_Course_Services_2015.pdf; Academic_Course_Regulation_EMC_HumanHazards.pdf

See also Author's Wiley & Sons Radio Spectrum Management: Policies, Regulations, Standards and Techniques ISBN-13: 978-1118511794; to be printed Apr16

Any Questions ?