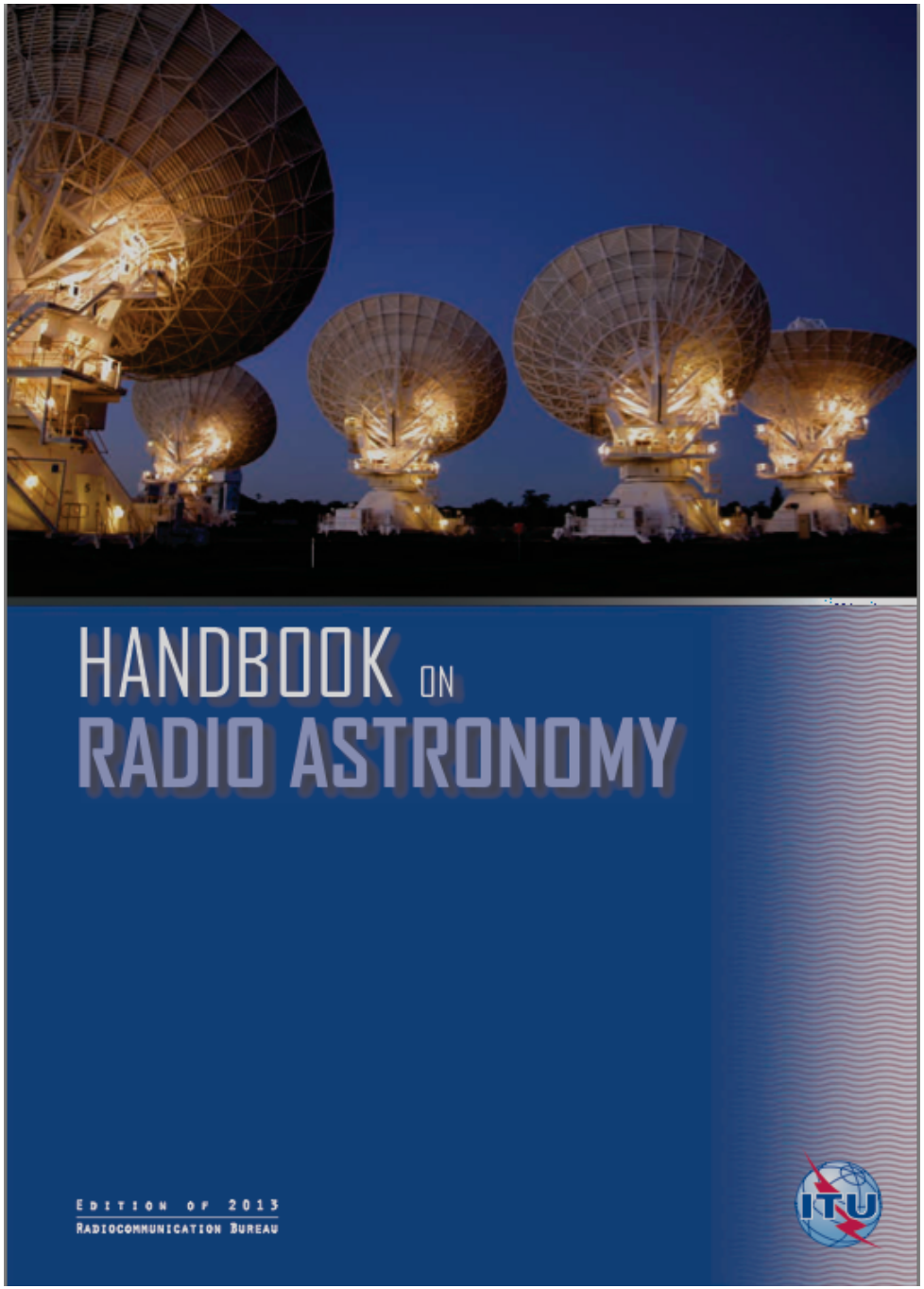
HANDBOOK ON
RADIO ASTRONOMY
EDITION OF 2013
RADIOCOMMUNICATION BUREAU
ITU

RAS Handbook - Summary

- Previous (2nd) edition 2003
  - 9 Chapters + 2 Appendices
- New (3rd) edition 2013
  - Almost all chapters updated
    - Except “Ground-based radar astronomy”
  - 3 New chapters
    - Includes “preamble” (Chapter 0)
  - 3 New Appendices

→12 Chapters + 5 Appendices

- Contributions from a large world-wide group

PREAMBLE
Radio Astronomy and Society

- 0.1 Introduction to astronomy
- 0.2 The role of radio astronomy
- 0.3 Economic and societal value
- 0.4 Solar Radio Monitoring

New - "must-read"

- Based on Report ITU-R RS.2178 (2010; 79 pp)
  - The essential role and global importance of radio spectrum use for Earth observations and for related applications

Chapter 1
Introduction *(regulatory)*

- 1.1 The Radiocommunication Sector and World Radiocommunication Conferences
- 1.2 The Radio Regulations and frequency allocations
- 1.3 Radio astronomy as a radiocommunication service
- 1.4 Frequency allocation problems for radio astronomy

*** General introduction to the regulatory environment.*

*** Most of these issues covered in detail in this school.*

CHAPTER 2
Characteristics of the Radio Astronomy Service

- 2.1 The RAS *(Definitions; history…)*
- 2.2 Origin and nature of cosmic radio emissions
- 2.3 Continuum
  - 2.3.1 Time variability of continuum radiation *(pulsars…)*
  - 2.3.2 Measurement of continuum radiation
- 2.4 Spectral-line radiation
  - 2.4.1 Types of spectral lines *(atomic; molecular; recombination)*
  - 2.4.2 Measurement of spectral lines
- 2.5 Modern Practice *(data volume; RFI mitigation)*

*** Technical aspects introduced*

CHAPTER 3: **Preferred** frequency bands for radio astronomy observations

- 3.1 General considerations
  - 3.1.1 Ground-based radio astronomy observations
  - 3.1.2 Space-based radio astronomy observations
- 3.2 Preferred continuum bands
  - 3.2.1 Observations at low frequencies
  - 3.2.2 High frequency bands for continuum observations
- 3.3 Bands for spectral-line observations *(Tables)*

*** Some technical considerations*

CHAPTER 4: Vulnerability of radio astronomy observations to interference

- 4.2 Basic considerations in the calculation of interference levels
  - 4.2.1 Detrimental-level criterion for interference
  - 4.2.2 Antenna response pattern
  - 4.2.3 Averaging time (integration time)
  - 4.2.4 Percentage of time lost to interference
- 4.3 Sensitivity of radio astronomy systems and threshold values of detrimental interference
  - 4.3.1 Theoretical considerations
  - 4.3.2 Estimates of sensitivity and detrimental interference levels
- 4.4 Response of interferometers and arrays to radio interference.
- 4.6 Achieved sensitivities
- 4.7 Discussion of interference
  - 4.7.1 Interference levels; 4.7.2 Interference from astronomical sources
  - 4.7.3 Special considerations for transmitters on geostationary satellites
  - 4.7.4 Filtering; 4.7.5 Interference levels capable of damaging or saturating a RA receiver
- 4.8 Monte Carlo analysis

****MOST important technical part → Rec ITU-R RA.769**

CHAPTER 5: **Sharing** the radio astronomy bands with other services

- 5.1.1 Protection criteria for the RAS
- 5.2 Separation distances for sharing with a single transmitter (Rec ITU-R RA.1031)
- 5.3 Sharing within LoS
- 5.4 Sharing with services with terrestrial transmitters
- 5.5 Sharing with mobile services
- 5.6 Sharing in radio astronomy bands below 40 GHz
  - 5.6.1 The band 1 330-1 427 MHz; -- 5.6.2 The band 4 800-5 000 MHz
  - 5.6.3 The bands 22.01-22.21 and 22.21-22.5 GHz
- 5.7 Sharing in radio astronomy bands above 40 GHz
  - 5.7.1 Sharing between 60 and 275 GHz
  - 5.7.2 Sharing above 275 GHz
- 5.8 Sharing with deep-space research
- 5.9 Time sharing
  - 5.9.1 Time and frequency sharing coordination

** SHARING is necessary and unavoidable

CHAPTER 6: **Interference** to Radio Astronomy from transmitters in other bands

- 6.1 *Regulatory definitions*
- 6.2 Limits for unwanted emissions from active services *(regulatory)*
- 6.3 Performance of radio astronomy receivers
  - Filtering of band-edge interference; Non-linear effects and intermodulation; Linearity; Filtering and digitization
- 6.4 Interference from transmitters of services in other bands
  - adjacent-band; harmonic; digital; satellites
- 6.5 Unwanted emissions from wideband modulation

**** Regulatory definitions and extensive RFI examples**

CHAPTER 7: Special techniques, applications and observing locations

- 7.2 VLBI, including Geodetic and Space VLBI
- 7.3 Radio astronomy from the L2 Sun-Earth Lagrangian point
- 7.4 Radio astronomy from the shielded zone of the Moon
- 7.5 Terrestrial sites with low atmospheric absorption
  - Antarctica; Cerro Chajnantor Chile; Mauna Kea; Arizona
- 7.6 Pulsar observations and application as time standards
- 7.7 Solar monitoring

**** Diversity of techniques & locations**

CHAPTER 8: Interference **mitigation**

- 8.2 Signatures of RFI sources and their impact
- 8.3 RFI Mitigation Methodologies - layers of mitigation
- 8.4 Pro-active methods - changing the RFI environment
- 8.5 Pre-detection & post-detection
- 8.6 Pre-correlation
  - Antenna-based digital processing; Adaptive (temporal) noise cancellation
  - Spatial filtering and null steering
- 8.7 At correlation
- 8.8 Post-correlation - before or during imaging
- 8.9 Implementation at telescopes - strategy

**** NEW. See also Report ITU-R RA.2126**

**** Increasingly necessary!!**

CHAPTER 9: Radio **quiet** zones

- 9.1 Definitions; general requirements; regulation
- 9.2 Considerations in developing an RQZ
  - Geographic; Frequency; RFI Impact
- 9.3 Electromagnetic environment
  - 9.3.1 Intentional radiators
  - 9.3.2 Unintentional radiators
  - 9.3.3 Propagation of interfering signals
- 9.4 Methods to achieve an RQZ
  - 9.4.1 Receive-side methods
  - 9.4.2 Transmit-side methods – Managing an RQZ
- 9.5 Implications in establishing an RQZ.

**** NEW. Details in Report ITU-R RA.2259**

**** Essential for new radio facilities (e.g SKA)**

CHAPTER 10: **SETI**

- 10.1 Intro to Search for Extraterrestrial Intelligence
- 10.2 Detectability of SETI signals .
- 10.3 Signal intensity
- 10.4 Receiving system sensitivity
  - 10.4.1 Minimum detectable signal power
- 10.5 Antenna pointing direction
- 10.6 Signal identification and interference rejection
- 10.7 Candidate bands to be searched

**** Updated. Technically difficult. RFI.**

**** Appeals to popular imagination**

CHAPTER 11: Ground-based **radar** astronomy

- 11.1 General Introduction
- 11.2 Sensitivity issues *(RFI vulnerability)*
- 11.3 Operational modes and bandwidth requirements
- 11.4 Radar astronomy installations

**** Active service!!!**

**** Unchanged from 2nd edition**

**** Spectrum Issues still important**

APPENDICES

- 1 Table of frequency bands allocated to radio astronomy *(Handy reference)*
- 2 Registration of radio astronomy stations
- 3 Units in radio astronomy
  - Translate between RA and other services
- 4 Practical uses of the dB scale
  - Very useful for quick calculations
- 5 List of Acronyms
  - Deciphering the jargon

Concluding Remarks

- Handbook provides introduction and guidance to spectrum issues for Radioastronomy.
- Very useful when starting in the spectrum management field but also as a reference.
- A resource and a guide. Updated every ~10 years!
- Produced and marketed by ITU-R but written entirely by volunteers. A big thank you to all!!
- Thanks to IUCAF for providing the copies and our Counselor at ITU (Vadim) for personal delivery!