Spectrum sharing, Dynamic Spectrum Access and White Space

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Cognitive Radio Systems Report M.2225

CRS may modify these **operational parameters**, not limited to the following parameters:

Output power; Operating frequency; Modulation type; Radio access technology

Potential benefits to system operators and end users

1. adding flexibility to assign RF
2. improving the efficiency of spectrum-use
3. improving the efficiency of power-use
4. benefits and the suitability of applications depend on the frequency band

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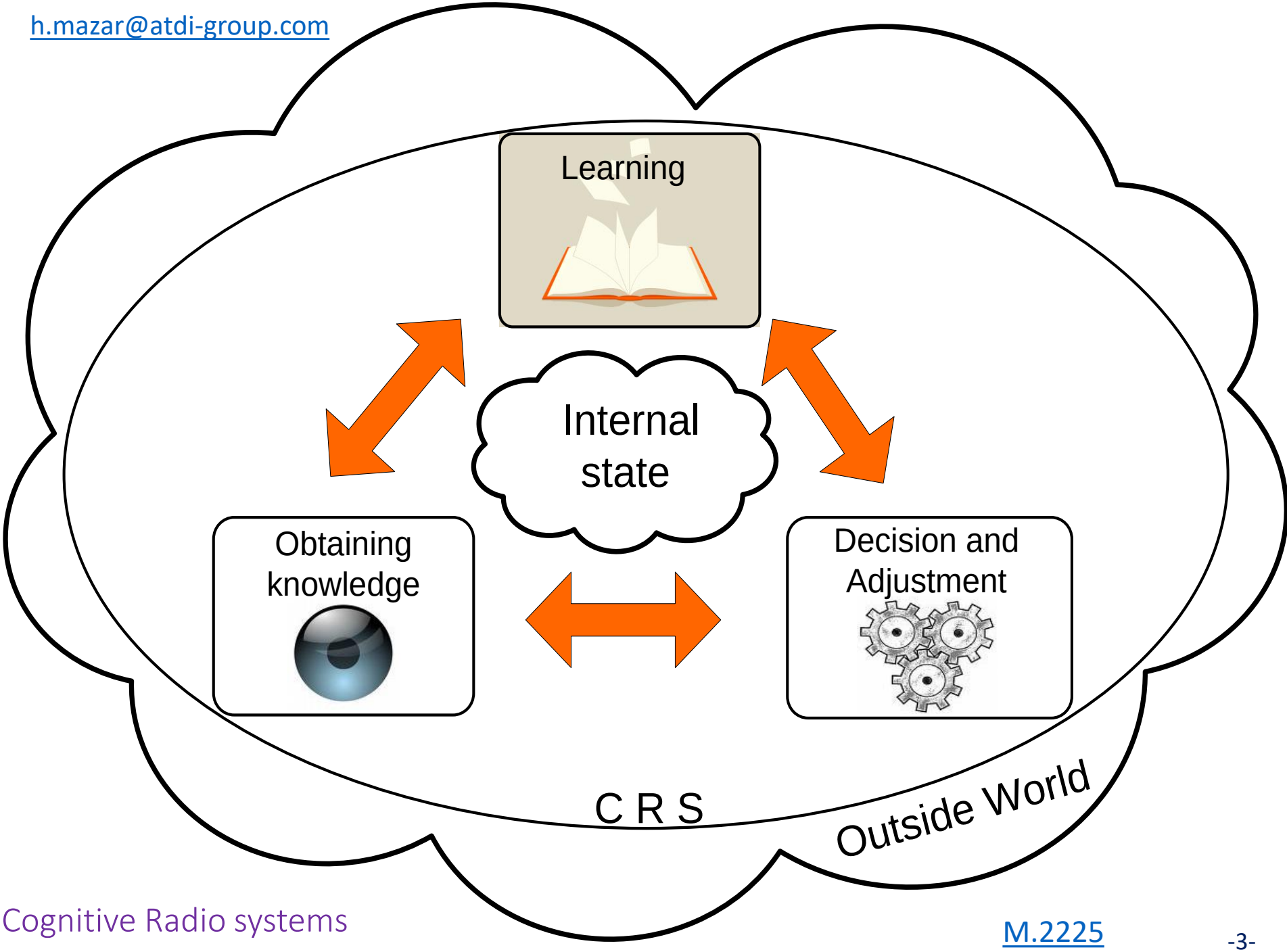
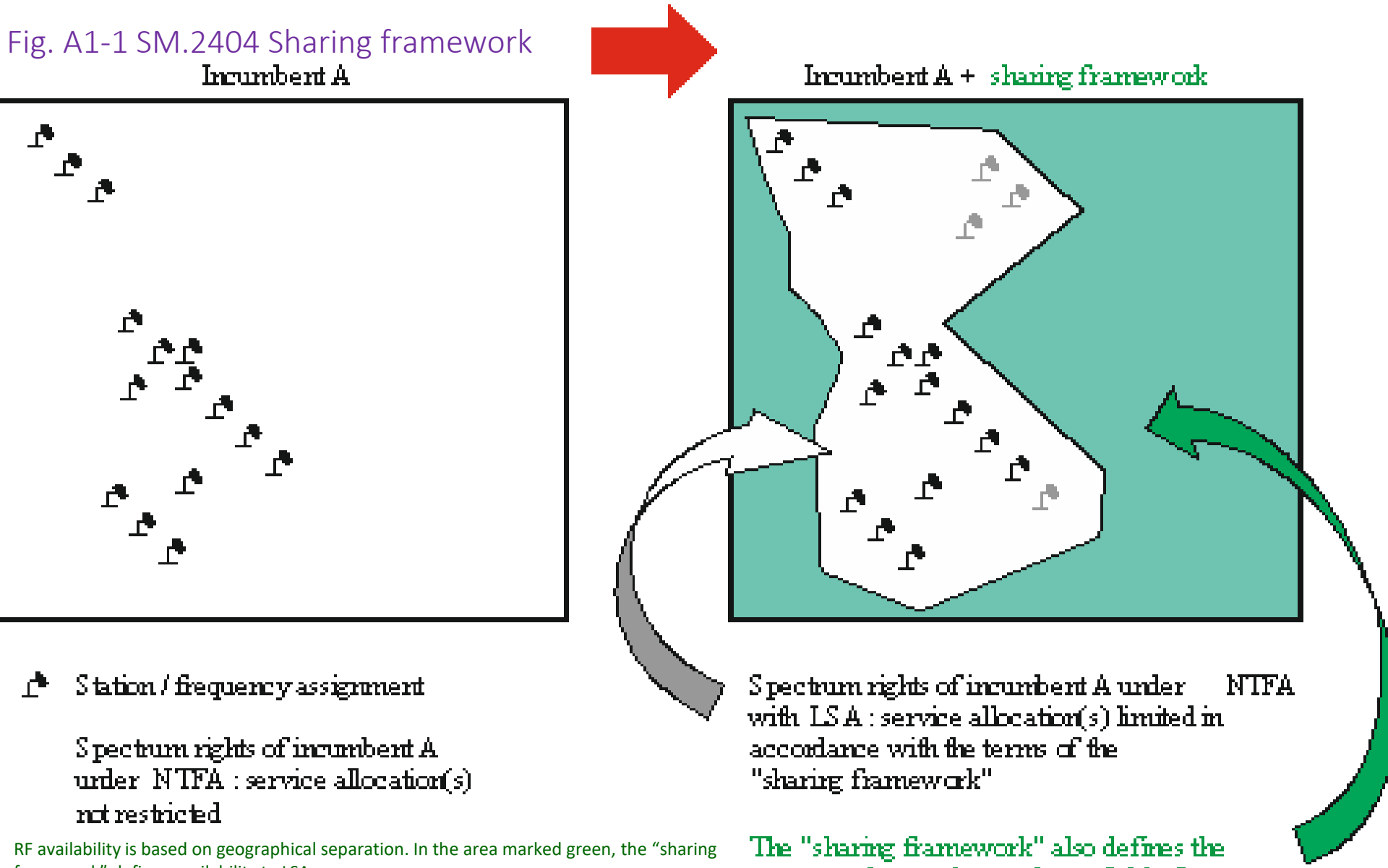


LSA as a complementary tool for spectrum management SM.2404

1. Licence Shared Access (LSA) is "A regulatory approach aiming to facilitate the introduction of radiocommunication systems operated by a limited number of licensees under an individual licensing regime in a frequency band already assigned or expected to be assigned to one or more incumbent users.
2. Under the LSA, additional users are authorised to use RF (or part of it) in accordance with sharing rules included in their rights of use of spectrum, thereby allowing all the authorised users, including incumbents, to provide a certain QoS.
3. In LSA the sharing can be done in the three dimensions, namely, time, frequency and area.

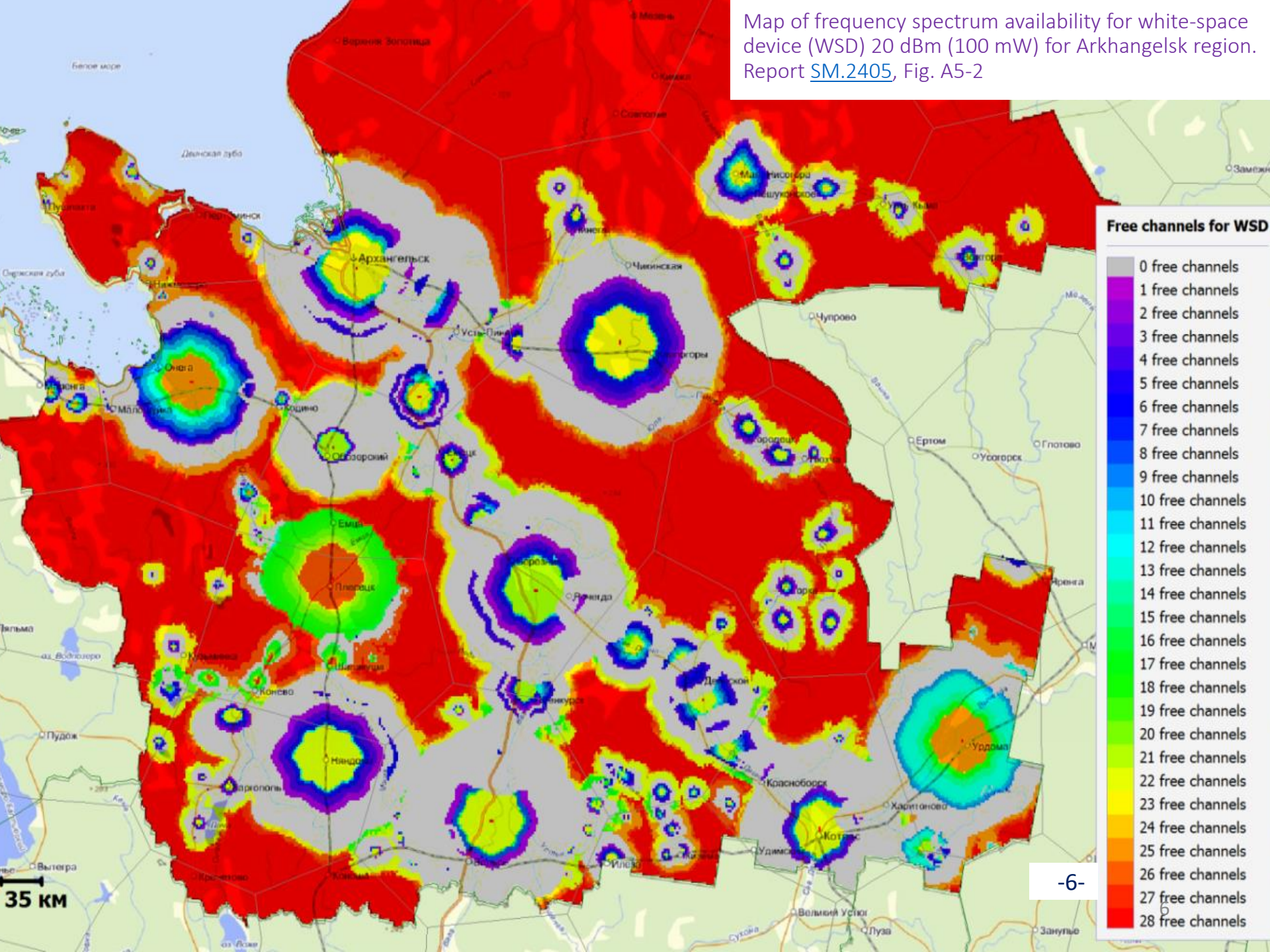
Fig. A1-1 SM.2404 Sharing framework



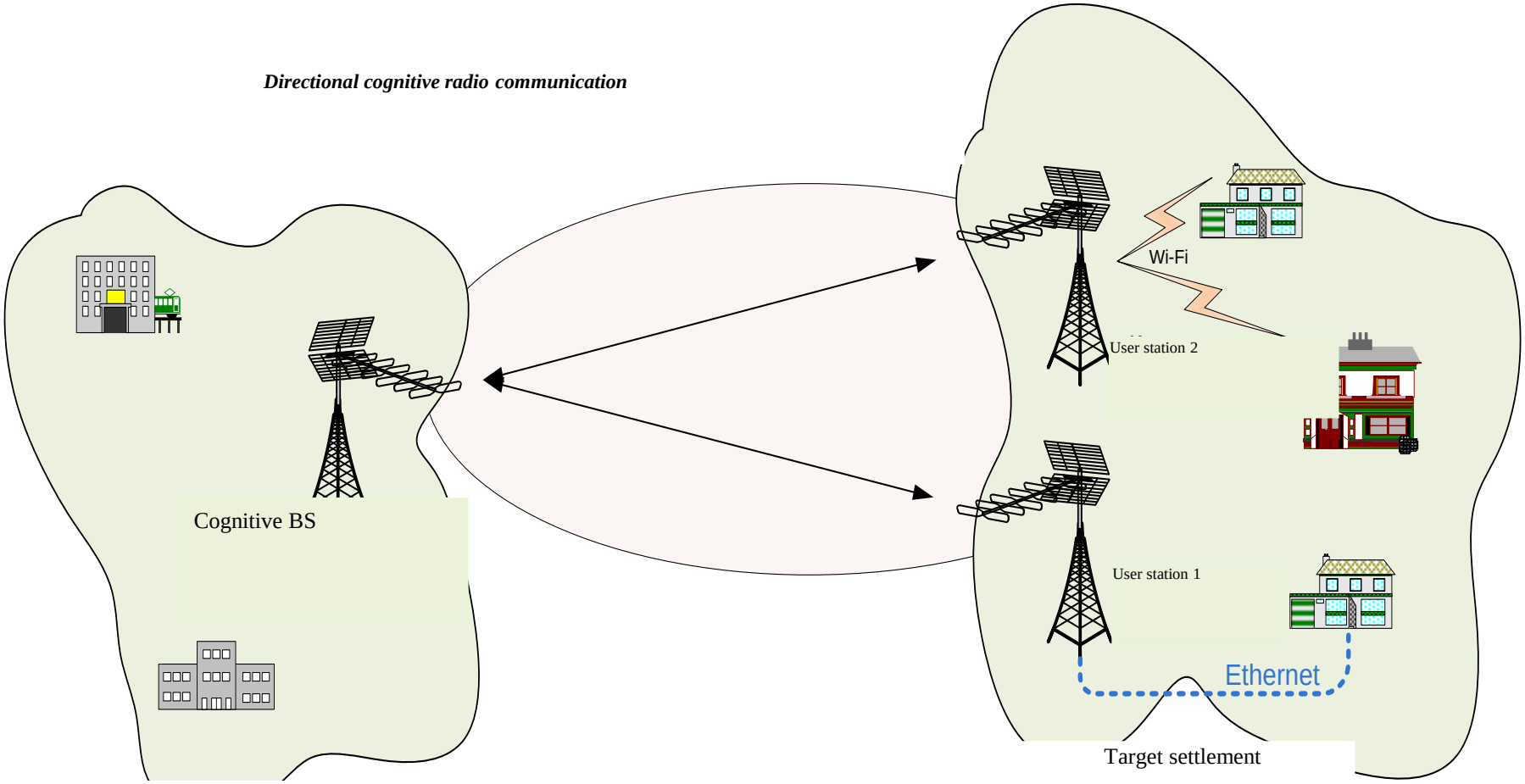
RF availability is based on geographical separation. In the area marked green, the “sharing framework” defines availability to LSA users

LSA takes into account for future needs of an incumbent, as depicted with grey stations in the Figure

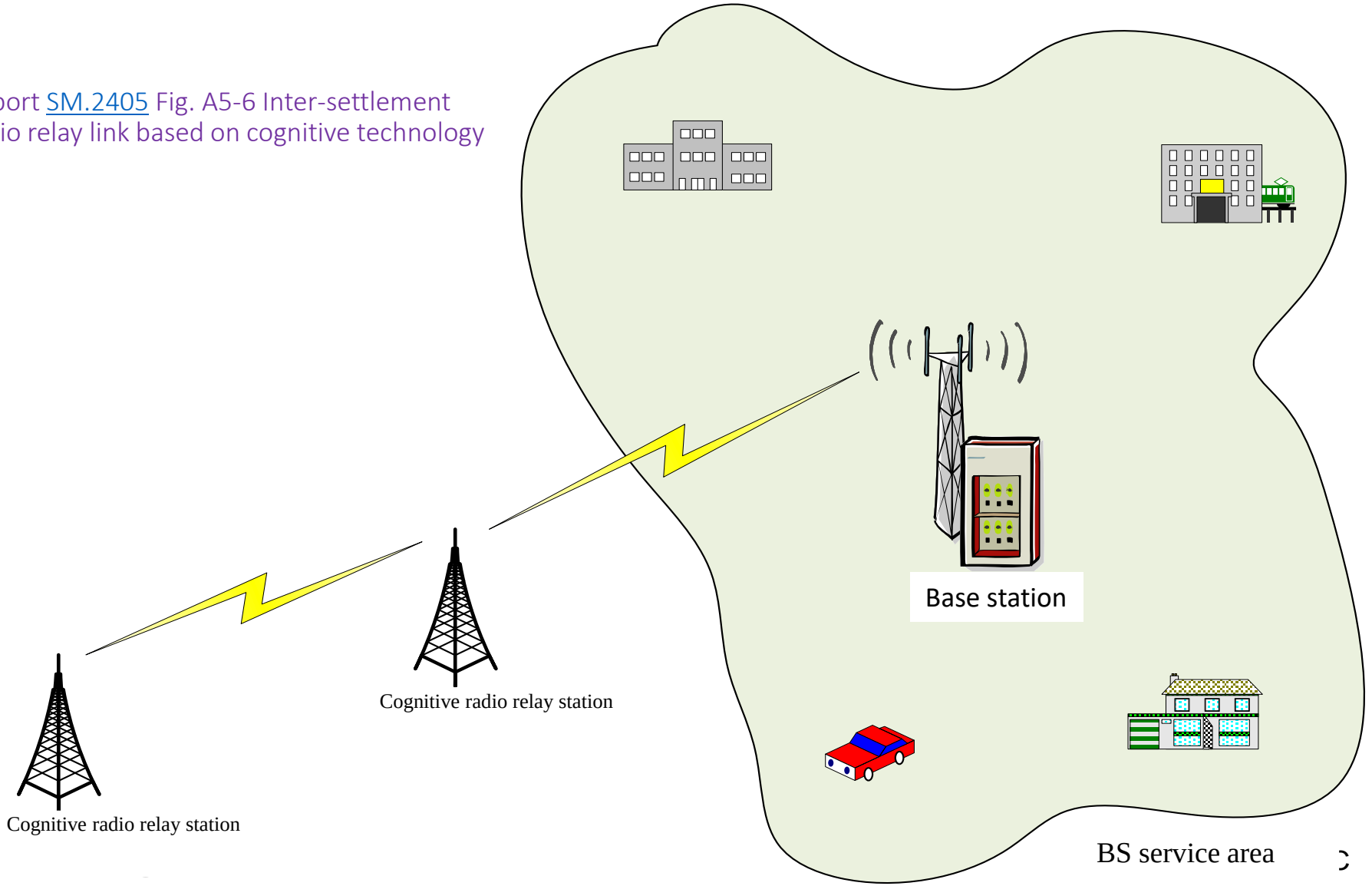
Map of frequency spectrum availability for white-space device (WSD) 20 dBm (100 mW) for Arkhangelsk region. Report SM.2405, Fig. A5-2



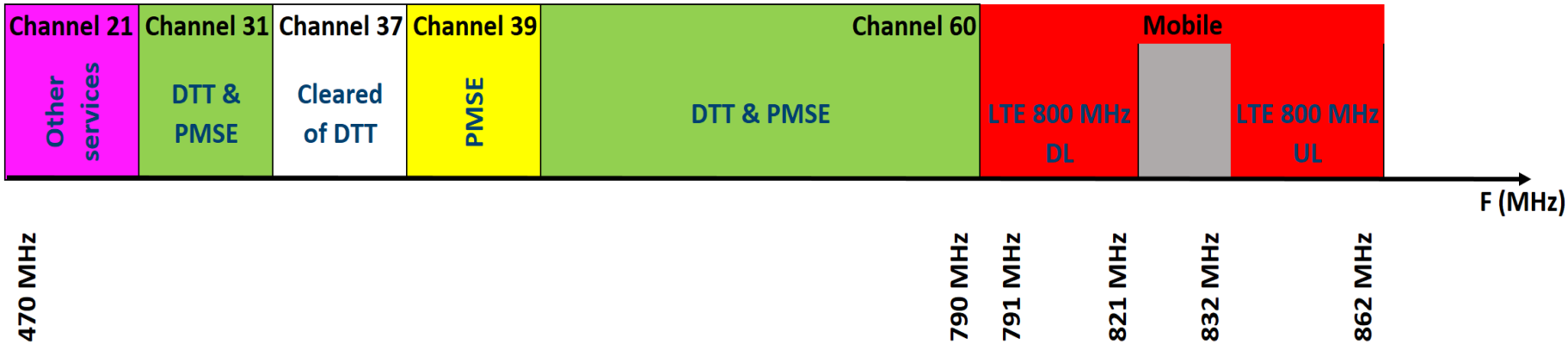
Directional cognitive radio communication



Report SM.2405 Fig. A5-6 Inter-settlement radio relay link based on cognitive technology



SM.2405 Fig. A7-1 Illustrative UHF TV band (470-790 MHz) and its European users



Based on ATDI experience

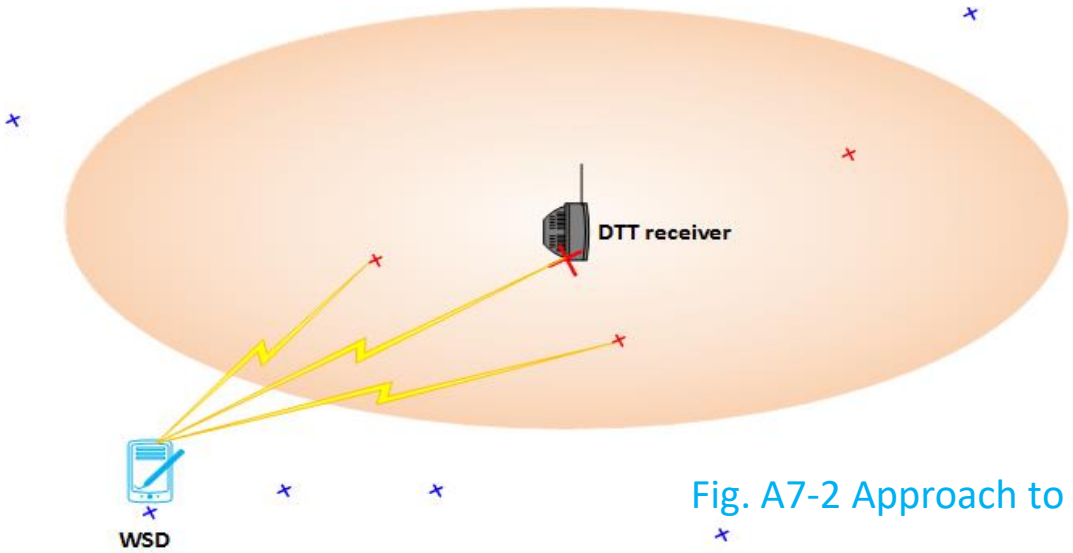


Fig. A7-2 Approach to build a WSD national database

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Method & Platform overview for TV white –space calculations & management; Report SM.2405

1. The main aim is to designate WSD RF in coverage gaps of TV channels
2. The method consists on identifying areas of availability of each TV channels
3. The following Fig. details the method to validate or invalidate the authorization
4. The platform contains three key units:
    1. TVWS calculation tool
    2. A management tool database
    3. A publishing tool or a dedicated website

Based on ATDI experience

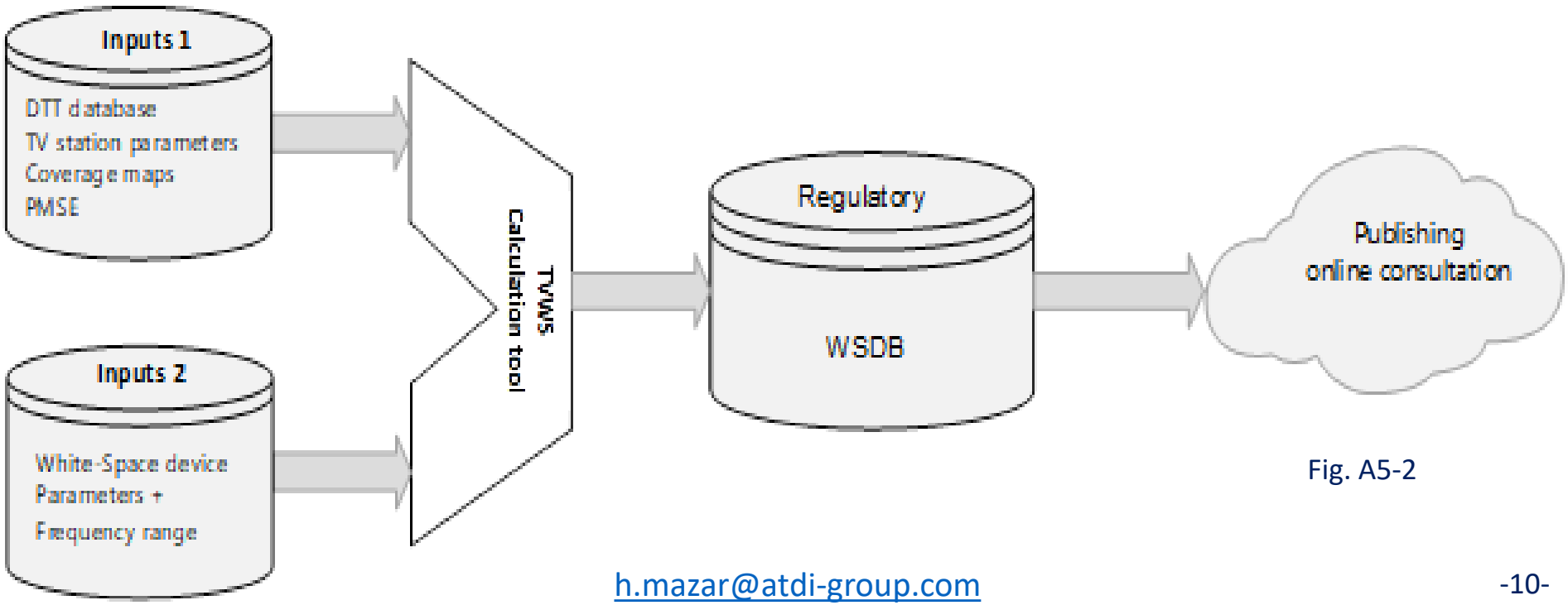
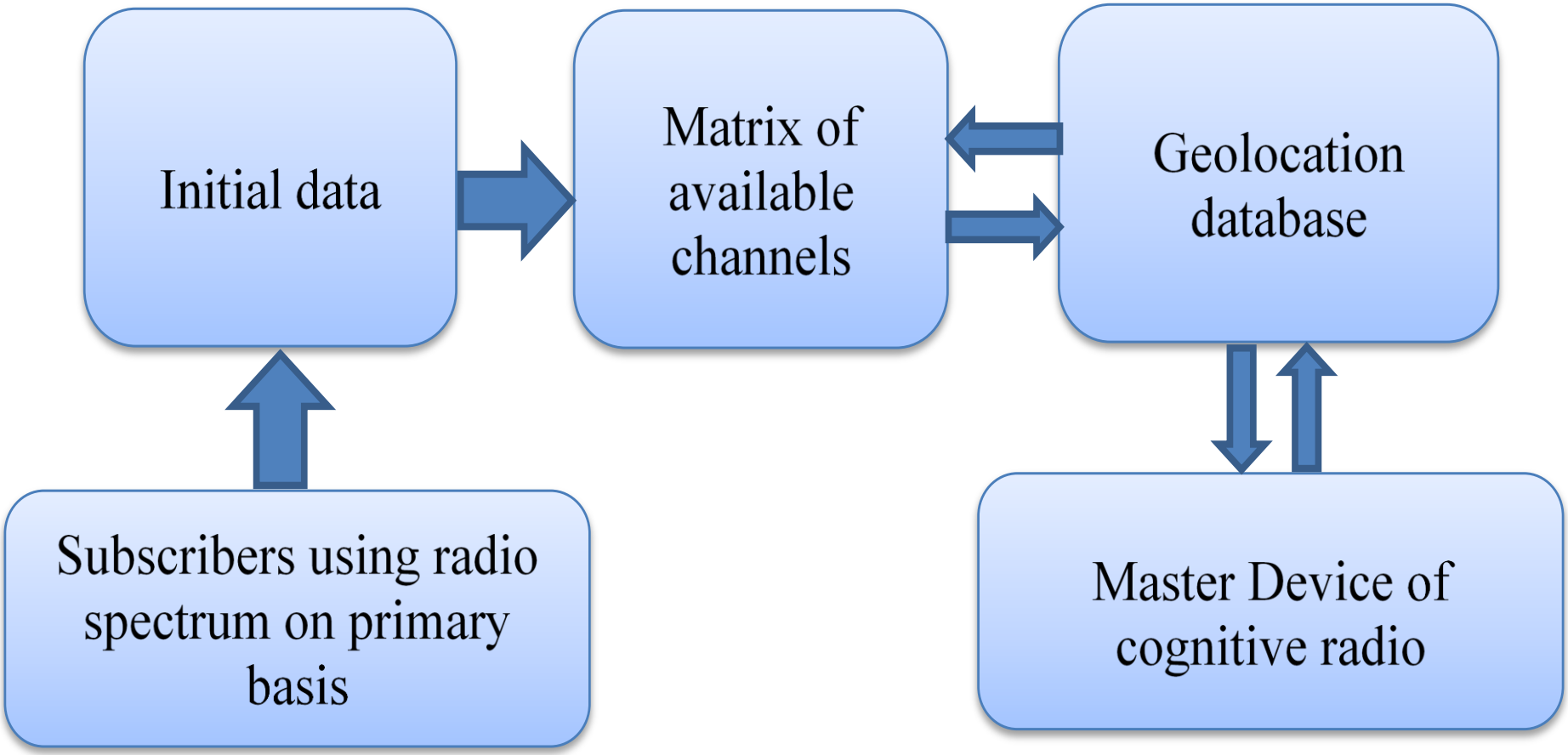


Fig. A5-2

Cognitive system using geolocation database Report SM.2405

The matrix of available channels is generated from the database on radio electronic devices with valid authorizations, and their specifications



RF to Operators Versus number of Sites, based on Shannon

Based on Shannon Hartley monumental paper (Shannon 1948 p. 43, theorem 17)
see Mazar 2016 –Radio Spectrum Management: Policies, Regulations and Techniques; 9.6.3

$$c = b \times log_2(1 + s/n)$$

1. Higher data rates oblige more RF spectrum and reduce the range achievable by the base station (WHO 2007 p.25-6 and155)
2. However, around the world, the RF Spectrum of cellular systems is the scarcest among wireless services, only comparable to the 87.5–108 MHz, FM radio broadcasting, known as Band II internationally.
3. As additional spectrum and active RF network-sharing (including RF spectrum) reduce the number of sites and human-hazards
4. Biglieri E., **Proakis** J. and **Shamai** (Shitz) S. October 1998 emphasize capacity, as the most important performance measure of cellular.

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$$c = b \times log_2(1 + s/n)$$

1. Shannon relates *c*apacity (bit/s), RF *b*andwidth (Hz) and the *s*ignal to *n*oise (dimensionless) ratio.
3. *s/n* depends on the distance from base-station
4. Trade-off between bandwidth *b* and power *s*: the capacity increases linearly with the increase bandwidth *b* (more influential), and only logarithmically with the increase in power *s*
5. Aim to Shannon Hartley capacity limit, by adding RF spectrum (*b*) and decreasing number of sites (*s/n*)
6. If *b* is increased *s/n* may be reduced, without harming the network's maximum capacity (*c*) and quality of service (when CDMA needs more capacity, radius of cells decreases)
7. The opposite is also true- operators install more sites, when RF spectrum is missing
8. Staying with the same *capacity*- less sites (reduced *s*) can be compensated by more frequency *band* (*b*)

Relevant Material from Dr. Haim Mazar presentations (1); see http://mazar.atwebpages.com/Downloads

1. Academic_Course_Advanced_Wireless_Communications_Mazar1_Engineering_2020.pdf
2. Academic_Course_Advanced_wireless_communications_Mazar2_Services_2020.pdf
3. Academic_Course_Advanced_Wireless_Communications_Mazar3_Regulation_EMC_HumanHazards_2020.pdf
4. Cameroon_EconomicModels_African_RF_Spectrum23Aug19French.pdf
5. Cameroon_Yaounde_Commonwealth_SM Forum_Mazar_Nov16_Spectrum re-farming.pdf
6. CamerounCellulaires_affectation_bande_470 694_21Dec18_French.pdf
7. CamerounSolutions_techniquesDTTV_MPT_UHF_21Dec2018_French.pdf
8. China_Beijing_SRMC 9July15_National Spectrum Control.pdf
9. China_Beijing_SRMC 9July15_SRD.pdf
10. China_Chengdu_National Spectrum Control Xihua University.pdf
11. Delft_Univ_Cultural_Factors_Shaping_RF_Spectrum_Governance_24Sept2010_Mazar.pdf
12. European vs North American Wireless Regulations_Mazar_ITU world telecom 2011_2633.pdf
13. Geneva_ITU-RSG1SG5-IoT-Workshop_Mazar_22Nov16.pdf
14. Heron5G_RF_regulations_6June19_Mazar.pdf
15. How_Geography_and_Culture_influence_RF_regulation_NZL_case_Wellington_4Feb2010_Mazar.pdf
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17. ITUD_Gambia_Optimised_Ways_to_Transmit_the_Video_Signals_16July2010_Mazar.pdf
18. ITUD_Gambia_Policies_and_Strategies_to_Optimise_RF_Spectrum_Use_14July2010_Mazar.pdf
19. ITU_regional_SM_conference_connecting_Yerevan13Dec2017.pdf

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Relevant Material from Dr. Haim Mazar presentations (2); see http://mazar.atwebpages.com/Downloads

20. ITU_regional_SM_workshop_parameters_Yerevan14Dec2017.pdf
21. ITU_workshop_international_regional_and_national_regulation_of_SRDs_Mazar.pdf
22. International_Regional_National_RF_Regulation_Standardisation_Ruppin_Mazar.pdf
23. International_Regional_National_RF_Spectrum_Management_13Dec2011_Afeka_Tel_Aviv_Academic_College_of_Engineering_Mazar.pdf
24. January 2016_National Spectrum Control_China@SRTC&XHU.pdf
25. January 2016_SRD_Mazar_SNG&SRTC&XHY&GDRTC.pdf
26. Lusaka_ZICTA_Auctioning_Training_30Sept-4Oct19_Mazar.pdf
27. Paper WT11 Technical Symposium TS11 Haim Mazar_A Comparison between European and North American Wireless Regulations.pdf
28. Presentation WT11 Technical Symposium TS11 Haim Mazar_A Comparison between European and North American Wireless Regulations.pdf
29. Regulating_SRD_Israel_MoC_28Jan2019_Mazar.pdf
30. Regulation of SRDs_Mazar_TCBC_Baltimore_15April2015.pdf
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