AUTORITÀ PER LE GARANZIE NELLE COMUNICAZIONI
AGCOM

World Dab Seminar
DAB+ planning, measurement and monitoring

DAB+ coverage planning from a spectrum regulator's perspective

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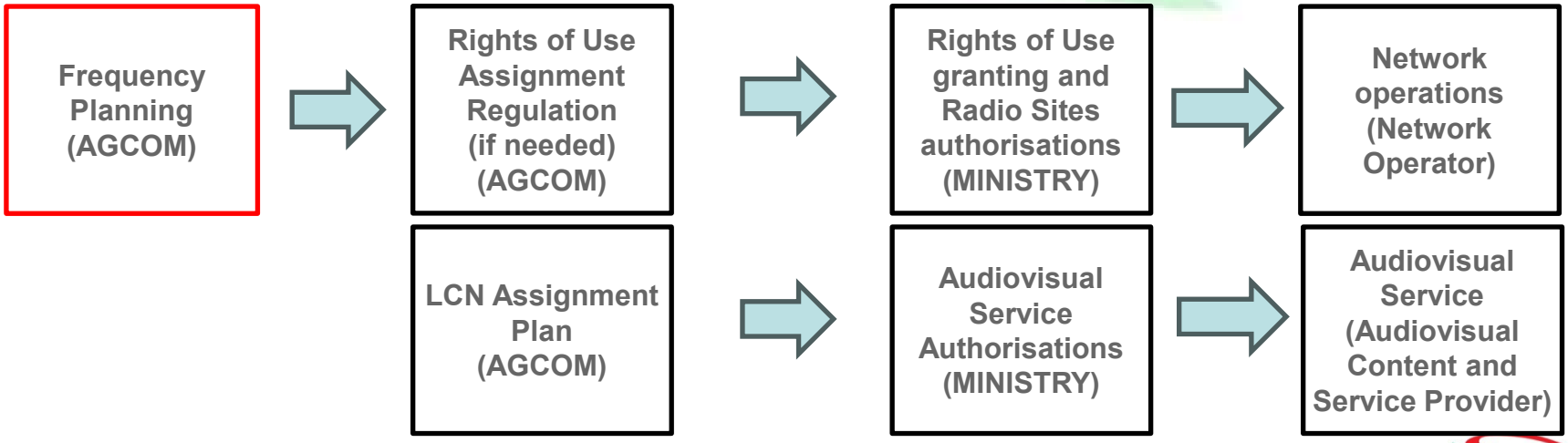
Spectrum regulation in Italy

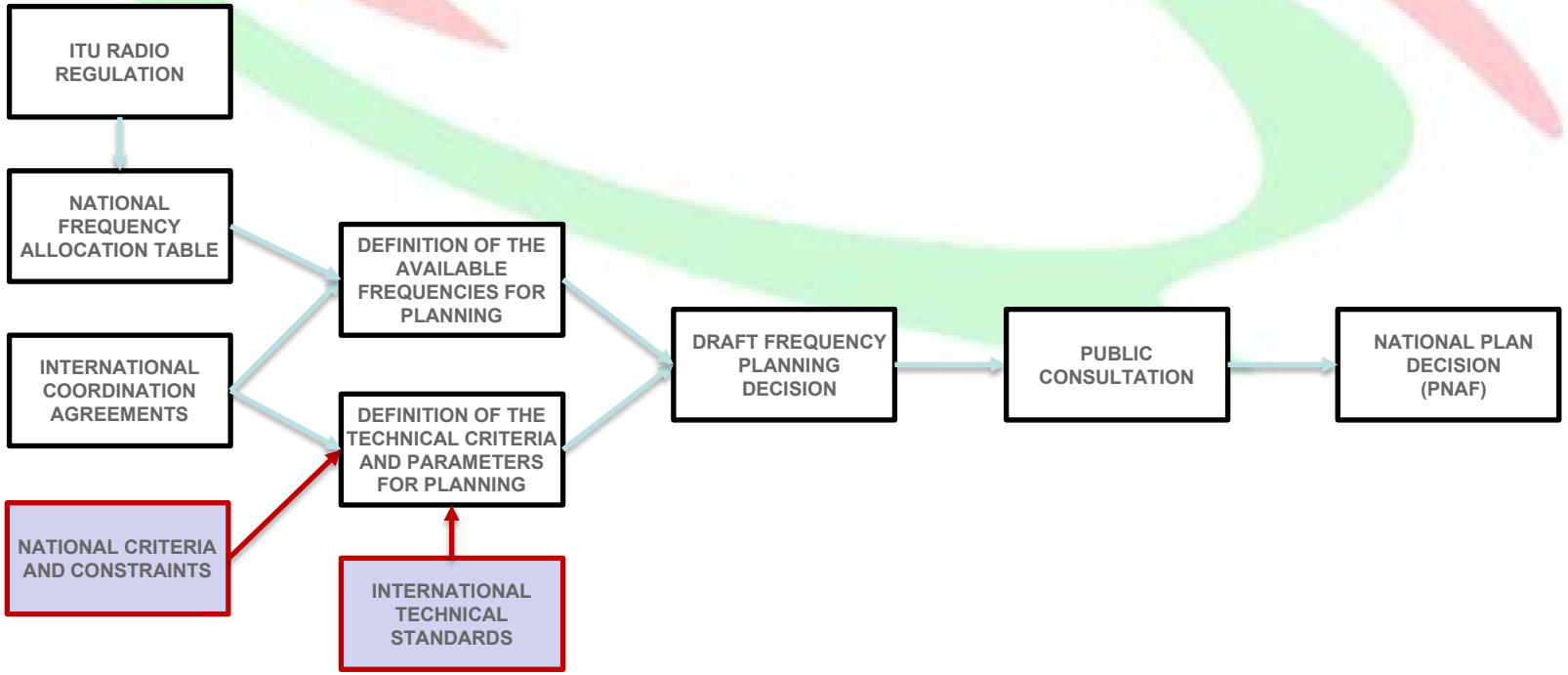
- In Italy, for spectrum matters, there is a sharing of responsibilities between the **Autorità per le garanzie nelle comunicazioni (Agcom)** and the Ministry of Enterprises and Made in Italy (MIMIT), set by Italian law (the Code)
- Agcom is the National Regulatory Authority in Italy and is independent from the Government
- Agcom is in charge of spectrum assignment plans (both in the telecommunications and broadcasting sectors) and is also responsible for the planning of the broadcasting frequencies
- MIMIT is in charge of spectrum allocation matters (National Frequency Allocation Table) and the administrative management of rights of use of spectrum, including carrying out the tender procedures

Broadcasting frequencies in Italy

- In Italy the frequencies for television and radio broadcasting services are planned with the s.c. *Piano nazionale di assegnazione delle frequenze* (PNAF-TV and PNAF-DAB)
- The name can be misleading because those plans actually concern network planning and not rights of use assignment
- The PNAFs are adopted through an Agcom's Decision (delibera)
- Implementation of PNAFs is competence of the Ministero delle Imprese e del Made in Italy (MIMIT)



Frequency planning process



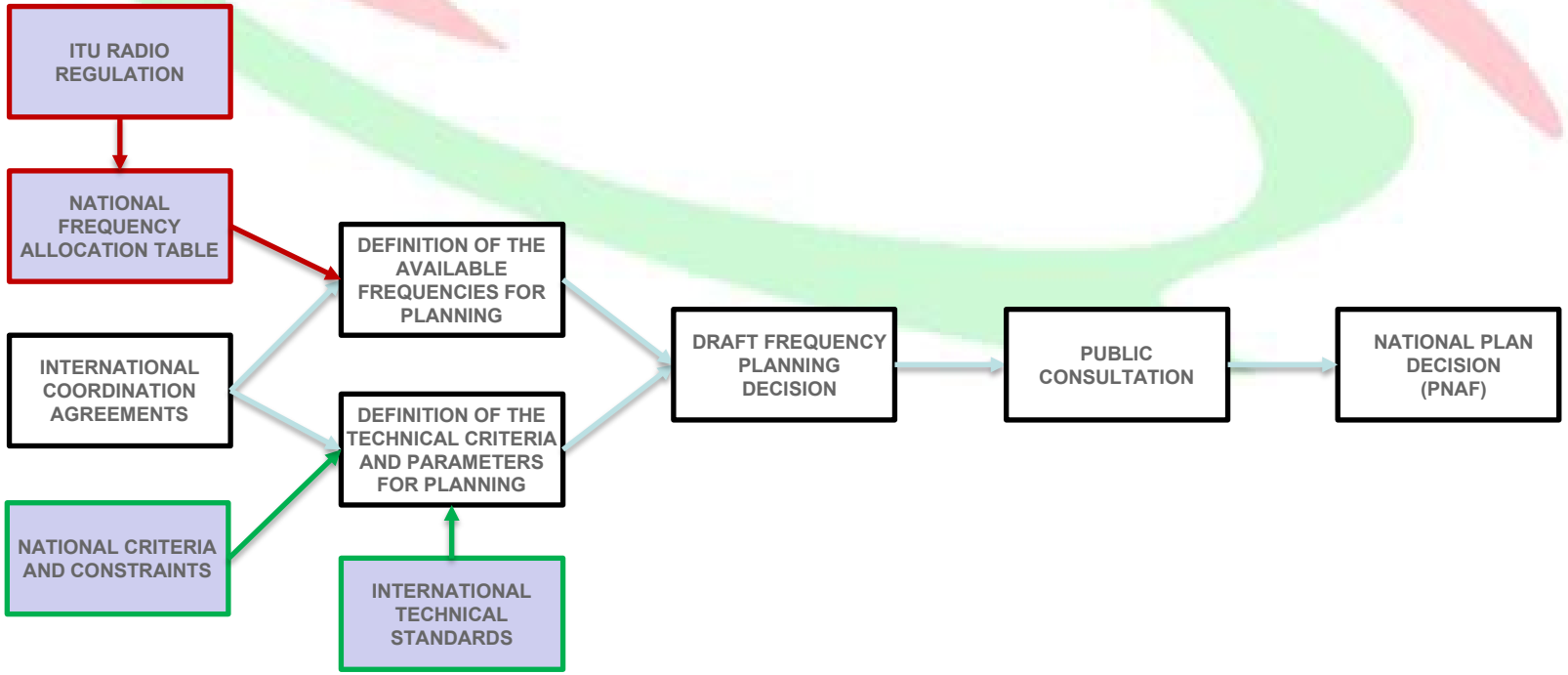
National Provisions, Criteria and Constraints

- Agcom needs to take account of provisions, criteria and constraints included in national legislations and other decisions that informs its frequency planning
- Examples in national legislations…
  - Audiovisual and Media Services Code (decree 8/11/2021, n. 208):
    - Use of the most advanced coding schemes and standards
    - Efficient spectrum use
    - Uniform coverage of national territory
    - Explicit provision of local service areas
    - Balanced distribution of frequency resources to national and local operators
    - Use of the sole frequencies internationally attributed to Italy
    - Priority destination of the band 174-230 MHz to digital radio with the possibility, where needed, of a limited television use
- …. and in past Agcom Decisions (decision n. 664/09/CONS, s.c. DAB Regulation)
    - At least 3 national networks (1 for the National Radio Television Public Service)
    - A suitable number of local networks
    - Coverage of population >= 70%

International standards

- Planning process must be transparent. Technical criteria and parameters used by Agcom in the PNAFs are published, in particular because they are used in activities carried out after planning decision:
  - Procedures for rights of use assignment and site authorisations (Ministry)
  - Surveillance on the obligations of the network operators (Ministry)
  - International frequency coordination (Ministry)
  - Design and roll out of the networks (network operators)
- For this objective we preferably use international standard and public domain data and reference models:
  - Propagation models based on ITU Recommendations (ITU-R P.1812, ITU-R P.1546) (so, no customised or proprietary models)
  - Public domain altimetric models (DEM) (NASA SRTM-90)
  - DAB planning parameters based on international documents (Report ITU-R BS.2214, EBU TECH 3391, GE06 Agreement Final Acts)
  - Demografic model (with population *raster*) based on national public data (ISTAT, the national statistics body)

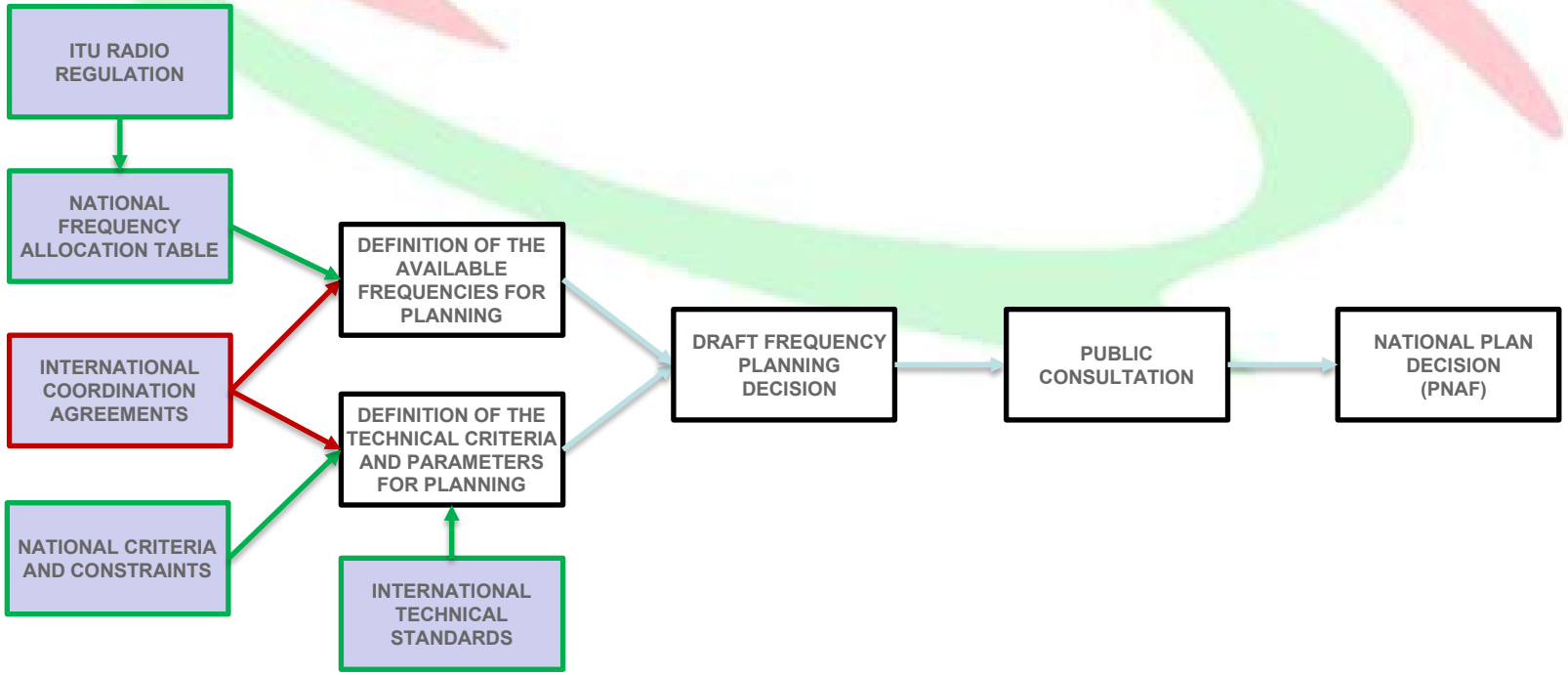
Frequency planning process



Frequency bands for DAB service

- Frequency bands allocated to the sound broadcasting service are initially defined at ITU level with the Radio Regulation (and the WRCs)
- In Italy the ITU Radio Regulation is taken in the national legislation with the National Frequency Allocation Table decision (in Italy PNRF)
- Italian NFAT allocates the digital terrestrial sound broadcasting services in the band 174-230 MHz (VHF-III)
- However, in the band VHF-III in Italy it is possible a limited use of television services where deemed necessary. In this respect, at the moment channel 5 in the Adriatic-Ionian and Tyrrhenian side of Italy is planned for a television network

Frequency planning process

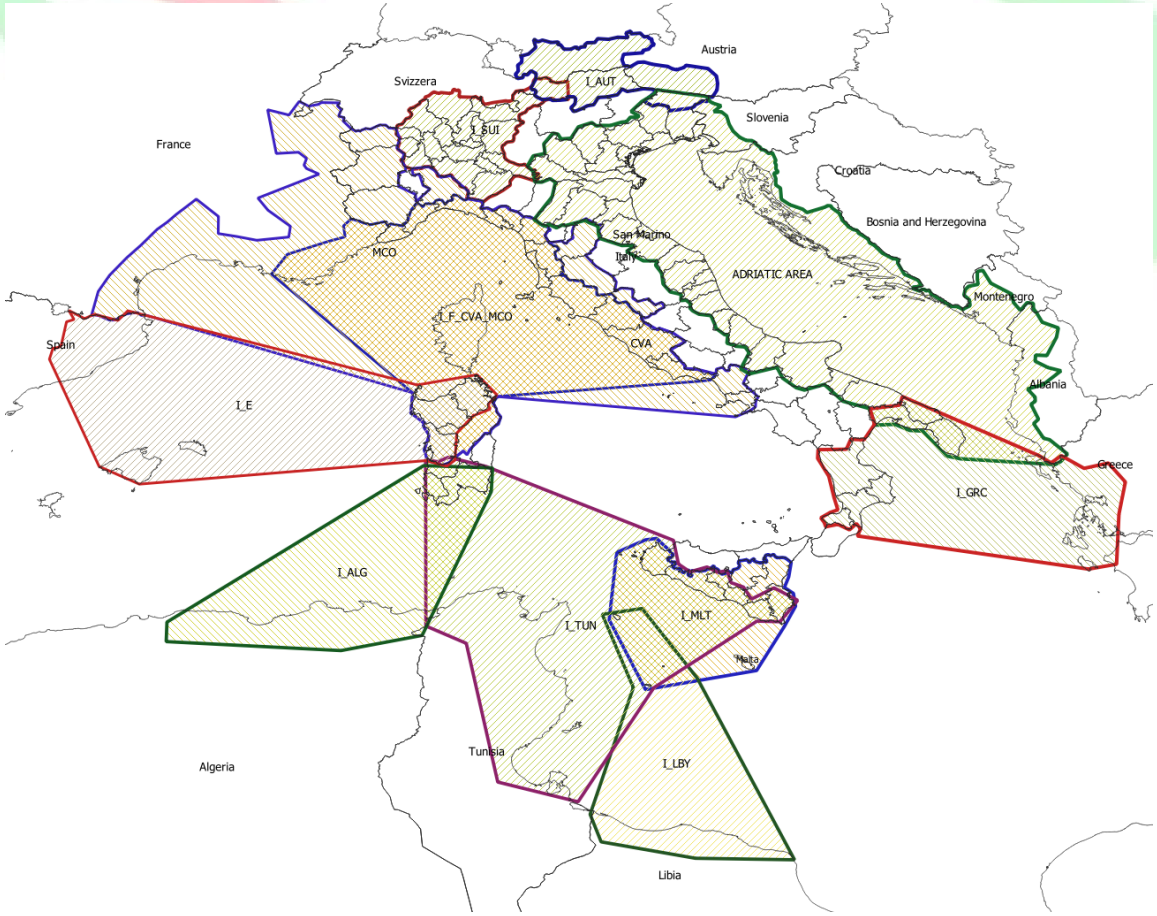


International coordination agreements (1/2)

- Italy borders radioelectrically a considerable number of foreign countries
- With those countries a number of international coordination agreements are in place
  1) Agreement GE06 (for **Slovenia, Croazia, Albania, Bosnia and Herzegovina, Montenegro, Greece, Tunisia, Libia, Algeria, Spain**)
  2) Agreement Italy-**Switzerland** (4/5/2018)
  3) Agreement Italy-**Austria** (11/10/2018)
  4) Agreement Italy-**Malta** (11/10/2019 and 22/1/2020)
  5) Tyrrhenian agreement between Italy, **France**, **Monaco**, **Città del Vaticano** (31/1/2020)
  6) Agreement Italy-**San Marino** (27/9/2021)
- A further agreement is still pending and in the negotiation phase: the Adriatic-Ionian agreement between Italy, Slovenia, Croatia, Bosnia and Herzegovina, Albania, Montenegro and Greece
- International coordination agreements are complex decisions that define:
  - The coordination areas (Italy is included in 10 different coordination areas)
  - Technical rules for frequency sharing
  - List of frequencies, both exclusive and shared, allocated to each country in the coordination areas

International coordination agreements (2/2)

The various international coordination areas affecting Italy, according to the currently in force agreements



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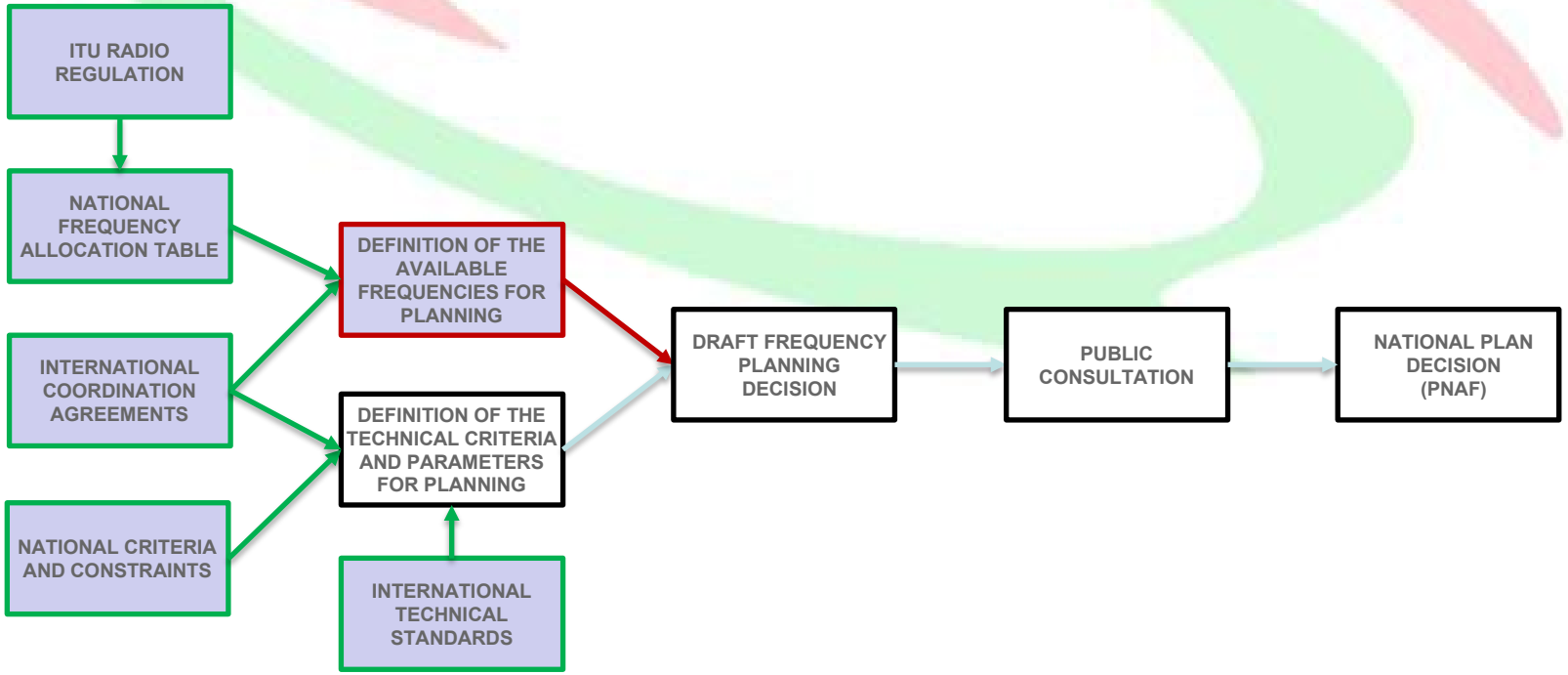
Frequency planning process

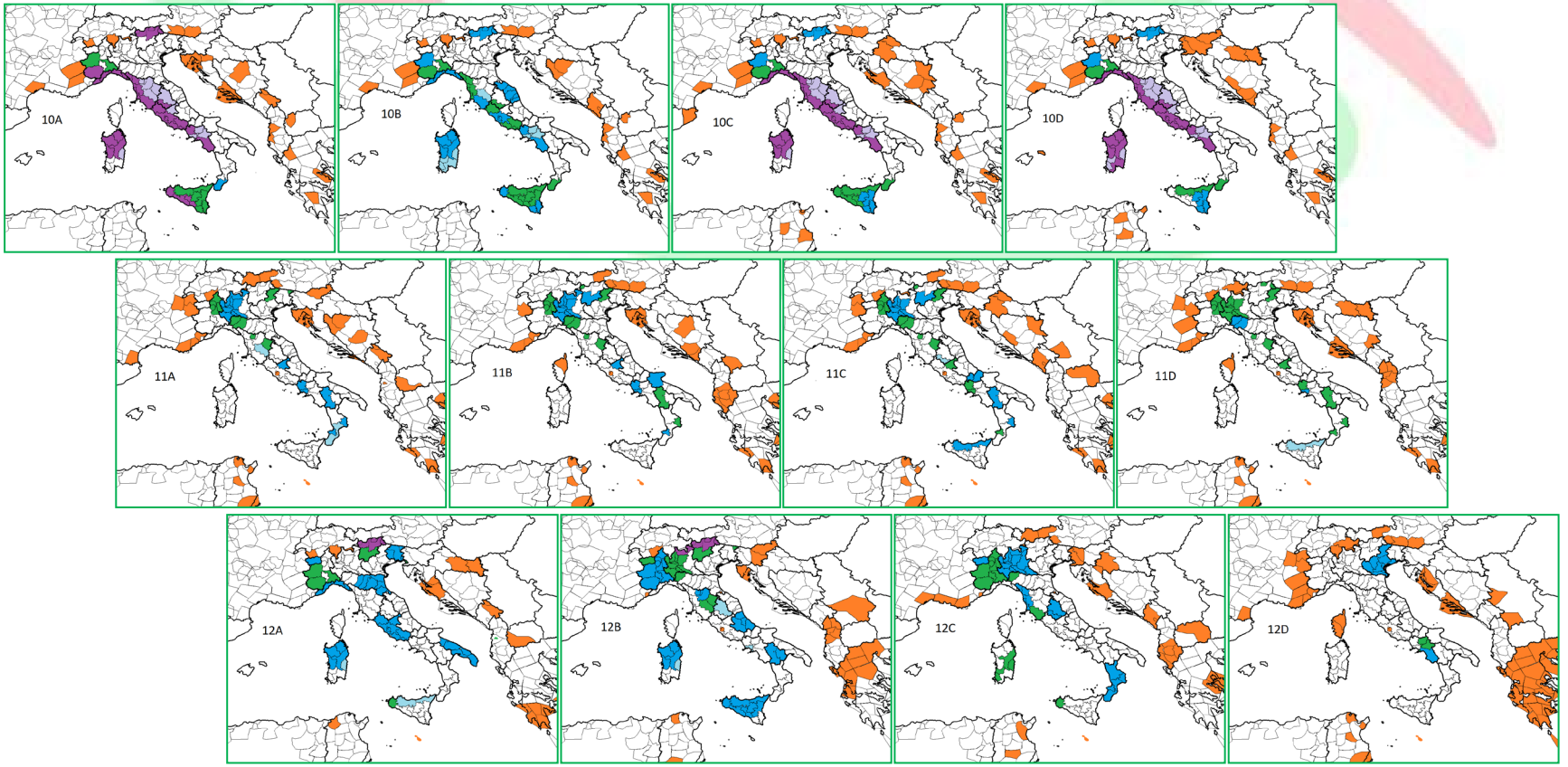


Frequencies available for planning (1/3)

- In the frequency band 174-230 MHz there are 56 MHz of spectrum
- The international channelling plan of the band 174-230 MHz defines 32 DAB blocks (from 5A to 12D)
- The spectrum resources should be equally split between neighbouring countries (*equitable access* principle)
- According to the currently in force agreements, around 13 DAB blocks (40% of the total blocks) in each coordination area are actually available to Italy for planning
- 1 channel (corresponding to 4 DAB blocks) is used for television services (as per law) in all areas
- With the remaining 9 DAB blocks, according to the legislative constraint, Agcom should plan at least 3 national networks and a «balanced» number of local networks
- Under the hypothesis that in each coordination area the 3 national networks are 1-SFN, then 6 blocks are available for local networks
- With a smart planning of local service areas, with a reuse level 2, it is targeted to plan at least 3 local networks in each identified service area (6:2=3)
- In conclusion, target objective of the Agcom DAB planning: 3 national multiplexes and 3 local multiplexes in each local service area

Frequencies available for planning (2/3)

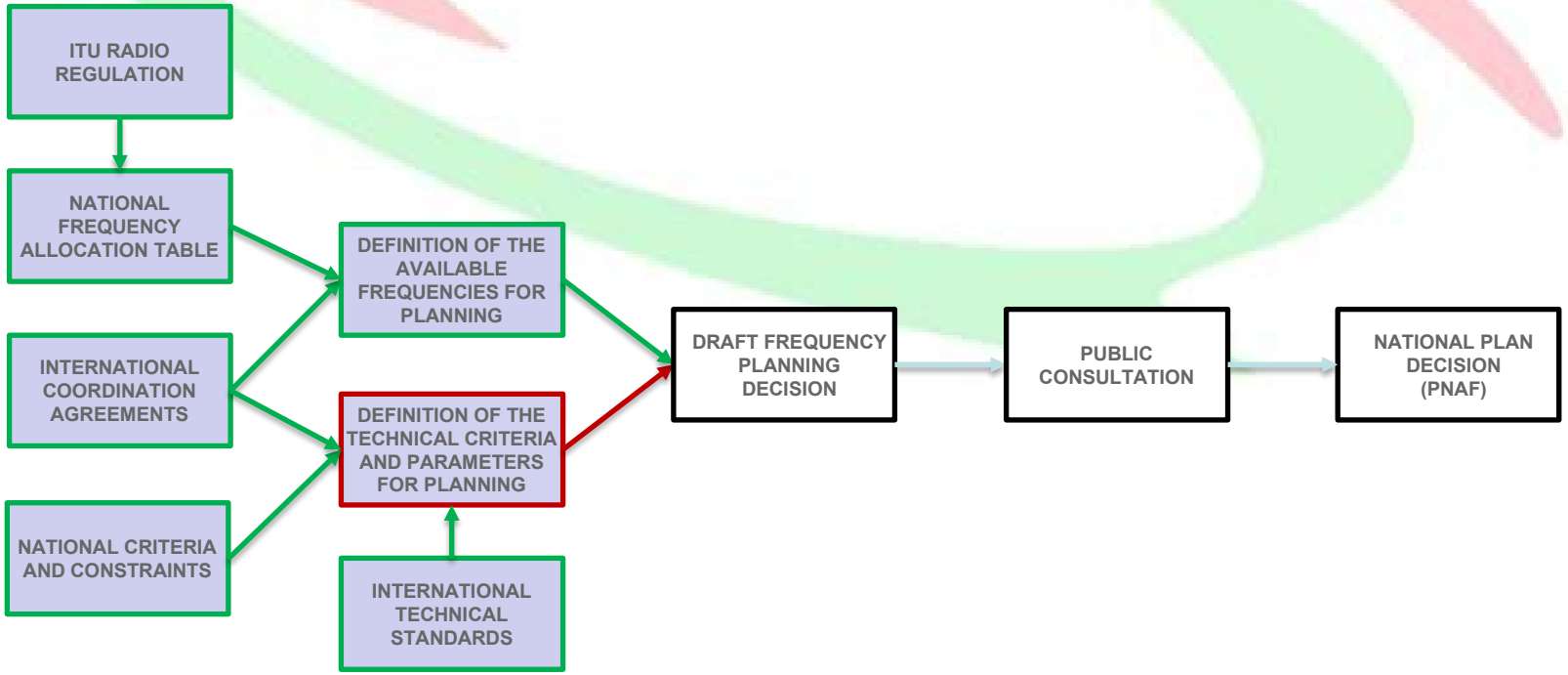
Examples of mapping of the frequencies allocated to Italy by the international coordination agreements to service areas



Frequencies available for planning (3/3)

Example of design of local service areas for a reuse 2 in the coordination areas

Frequency planning process



Technical criteria and parameters in planning (1/3)

- Planning criteria of PNAF-DAB
  - National networks
    - Objective: at least 3 national networks (by law)
    - No need of content decomposability on local areas (this was later contested by one operator)
    - Extensive use of configurations 1-SFN -> max efficient use
  - Local networks:
    - Objective: find a balanced solution amongst contrasting needs
      - Efficient use of the spectrum
      - Decomposability needs of local contents
      - Reasonable distribution of the limited resources
    - Differentited decomposability:
      - *layer* with configuration 1-SFN with regional extension non-decomposable (more efficiency)
      - *layer* with configuration k-SFN with regional extension decomposable (mix efficiency-market needs)
      - additional local *layer* with extension sub-regional
  - Population coverage objective: >= 70%

Technical criteria and parameters in planning (2/3)

- Technical references in the definition of the PNAF-DAB
  - Report ITU-R BS.2214-5 (10/2020) "*Planning parameters for terrestrial digital sound broadcasting systems in VHF bands*"
  - Report EBU TECH 3391 "*Guidelines for DAB network planning*" (Geneva, 2018)
  - Geneva Agreement 2006, Annex 2 "*Technical elements and criteria used in the development of the Plan and the implementation of the Agreement*"
- Definition of the reference configuration for planning (*Reference Planning Configuration*-RPC)
  - Transmission standard: DAB+ (ETSI EN 300 401; ETSI TS 102 563)
  - Reception mode: mobile (prevailing user in vehicle)
  - Receiving antenna height: 1,5 m
  - Channel model: Rayleigh
  - T-DAB mode: 1 (terrestrial VHF)
  - Bandwidth: 1,536 MHz
  - Useful symbol duration: 1.000 µs
  - Guard interval duration: 246 µs
  - Error Protection: EEP-3A
  - Code Rate: 1/2
  - Co-channel protection ratio: 12,6 dB
  - Minimum median equivalent field strenght: 42,84 dBµV/m (at 200 MHz)
  - Minimum reception quality: Coverage Probability >= 95% (intermediate value between «*good*», 99%, and «*acceptable*», 90%)

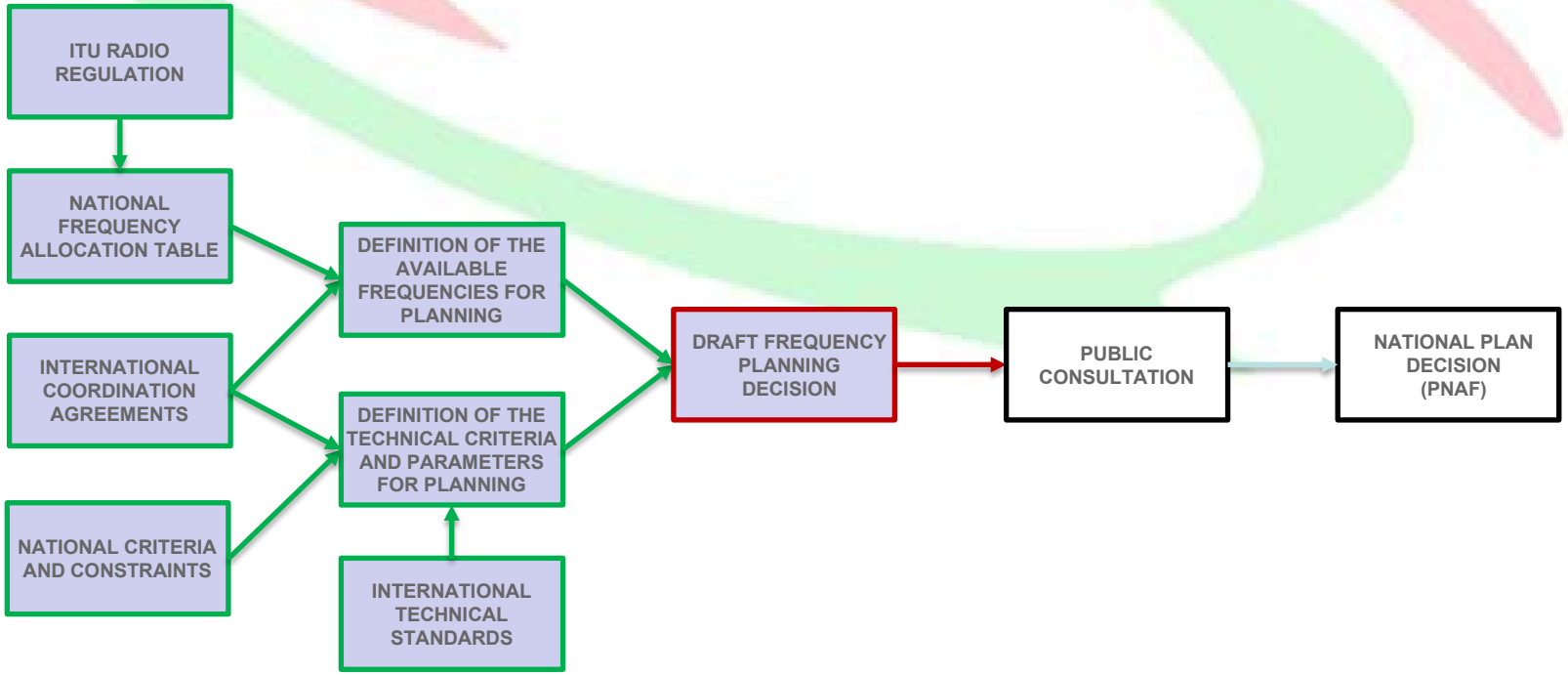
Technical criteria and parameters in planning (3/3)

- Propagation models that have been used
  - Recommendation ITU-R P.1812-5 (08/2019) "*A path-specific propagation prediction method for point-to-area terrestrial services in the VHF and UHF bands*"
  - In case of propagation prevailing above the sea: Recommendation ITU-R P.1546-6 (08/2019) "*Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3000 MHz*" (statistical)
  - Parameters for the field strength prediction:

	Useful signal (condition *steady*)	**Interfering signal (condition *tropo*)**	
		National Territory	Foreign country territory
Time probability	50%	10%	1%
Location probability	50%	50%	50%

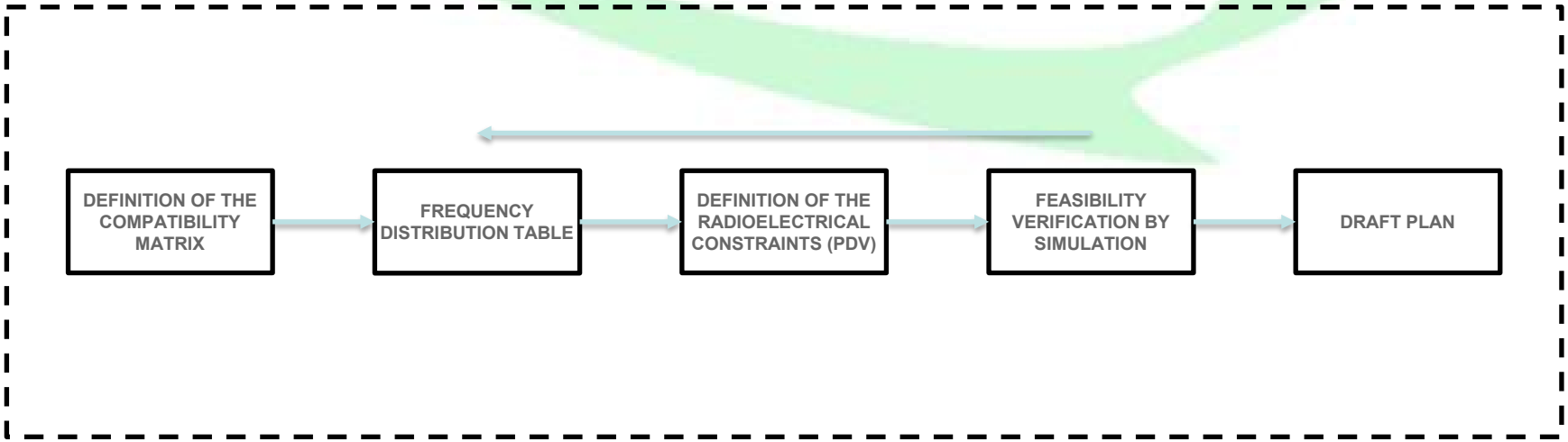
- Receiving antenna height: 10m above ground (correction at 1,5m with the *Height Loss Correction Factor*)
- Digital Elevation Model: DEM NASA SRTM 90 metres
- Signal summation method: T-LNM (EBU BPN 005) and Power Sum

Frequency planning process



Draft Frequency Planning Decision (1/6)

- Initially a draft Plan should be prepared
- It is an iterative process that is developed through different phases



Draft Frequency Planning Decision (2/6)

- Definition of the compatibility matrix (between areas)
  - Local service areas are divided into elementary units of territory (called allotments) that cannot be further decomposable; in each allotment it is hypothesized the use of a given frequency
  - Usually, the allotments correspond to the territory of a single Italian province
  - Compatibility between two allotments is evaluated on the basis of the potential coverage and interference of the main real transmission sites existing within them, considering their typical radiation characteristics
  - The compatibility matrix shows whether any two allotments are:
    - Compatible (i.e. they can share the same frequency)
    - Partially compatible (i.e. they can share the same frequency depending on Tx parameters)
    - Incompatible (i.e. they must use different frequency)
  - A single local service areas is then formed by grouping a number of allotments that are by definition compatible

Draft Frequency Planning Decision (3/6)

- Definition of the frequency distribution table
  - It is the most complex phase in the planning process
  - All frequencies available after international coordination agreements in the various coordination areas are distributed to the various allotments, taking into account
    - the compatibility matrix
    - the configuration of the service areas
  - Objective:
    - maximise frequency reuse
    - minimise the number of frequencies used for each planned network
    - planning the highest possible number of networks

Draft Frequency Planning Decision (4/6)

- Definition of the radioelectrical constraints
  - The PNAF does not impose the use of specific sites to each network; it defines a radioelectrical constraints framework to be respected, both over the national territory and over the territory of the radio neighbouring foreign countries
  - Those constraints are defined and enforced through the tool called Points of Verification (PDV in Italian)
  - Any PDV is a *test point* for each planned frequency (more appropriately a *calculation point*) geographically defined, located on the national or foreign territory, with an associated threshold aimed at protecting that same planned frequency
  - The PDVs are distributed over the territory, both the national and the foreign country's, according to a regular grid at 96 seconds steps in latitude and longitude
  - The threshold for the Italian PDVs is derived from the Reference Planning Configuration (see previous) and corresponds to the maximum value of the aggregated interfering field that can be tolerated in that PDV in order to guarantee the desired reception quality (CovProb>=95%) at a given frequency. At the reference frequency (200 MHz) this threshold is 39,9 dBµV/m
  - The threshold for PDVs in the foreign territory is derived on the basis of the technical rules in the applicable international coordination agreements (similar order of magnitude)

Draft Frequency Planning Decision (5/6)

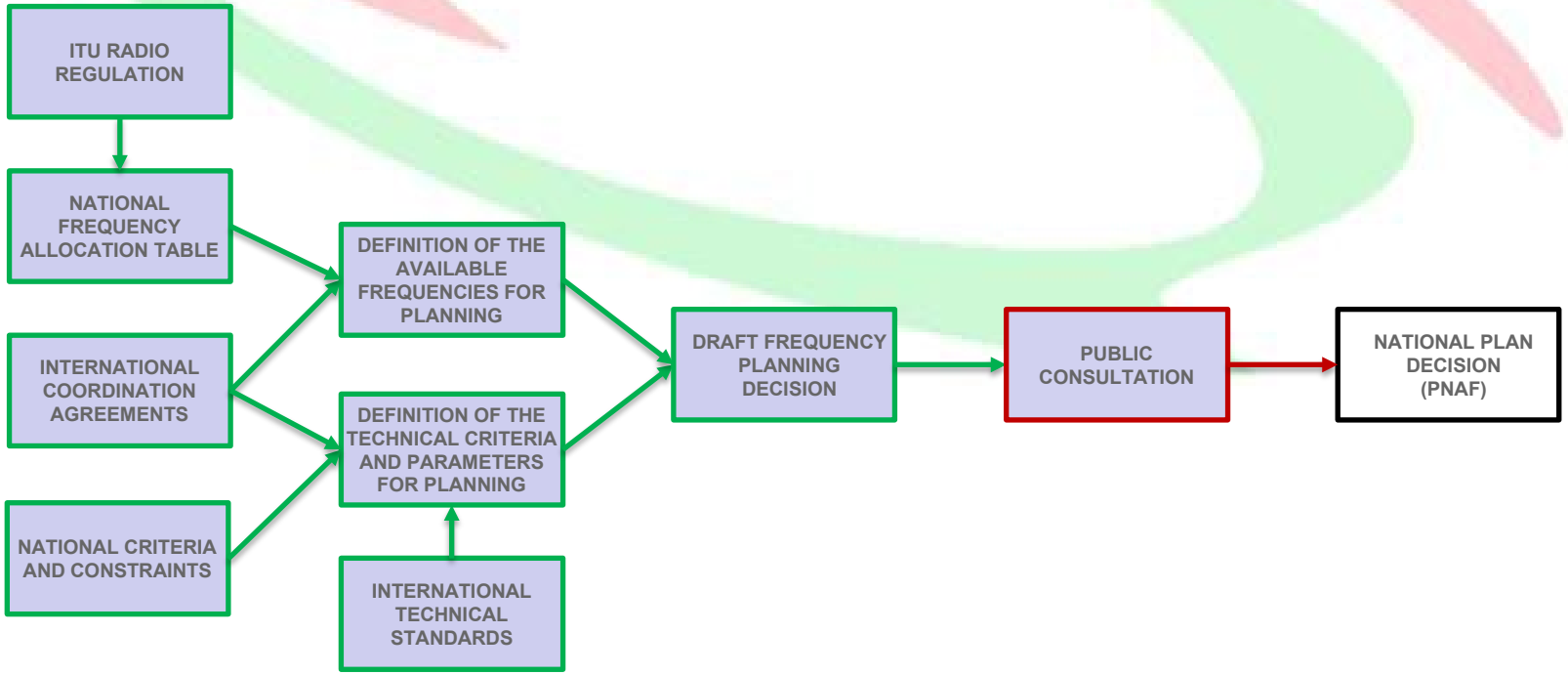
- Example
  - Mapping of radioelectrical constraints, national and foreign, defined by PNAF-DAB for the block **12A**
  - Local network operator «**A**» is granted block **12A** in a local service area corresponding to a region in Centro Italia (Lazio)
  - It can use 12A in any transmission site in its service area at the condition of respecting the interference threshold in all PDVs where the riuse of the same block is planned (protecting **12A** of the other operators in the PDVs)
  - At the same time, through the pertinent agreements, it knows the maximum level (threshold) of interference that should accept

Draft Frequency Planning Decision (6/6)

- Feasibility verification by simulation
  - The frequency distribution table need to be verified in order to be feasible
  - To this aim Agcom defined theoretical network models, yet based on real equipment and sites (reference networks)
  - With state-of-the-art simulation software* Agcom verifies that the reference networks can reach the coverage objectives while at the same time respecting the radioelectrical constraints
  - When the verification is negative, the frequency distribution table is modified and the process is re-iterated

* LS telcom *CHIRPLUS_BC* software installed on a FUJITSU PRIMERGY BX2560 M1 server based on Intel Xeon CPU E5-2650 v3 @ 2.30 GHz (20 cores/40 logical processors)

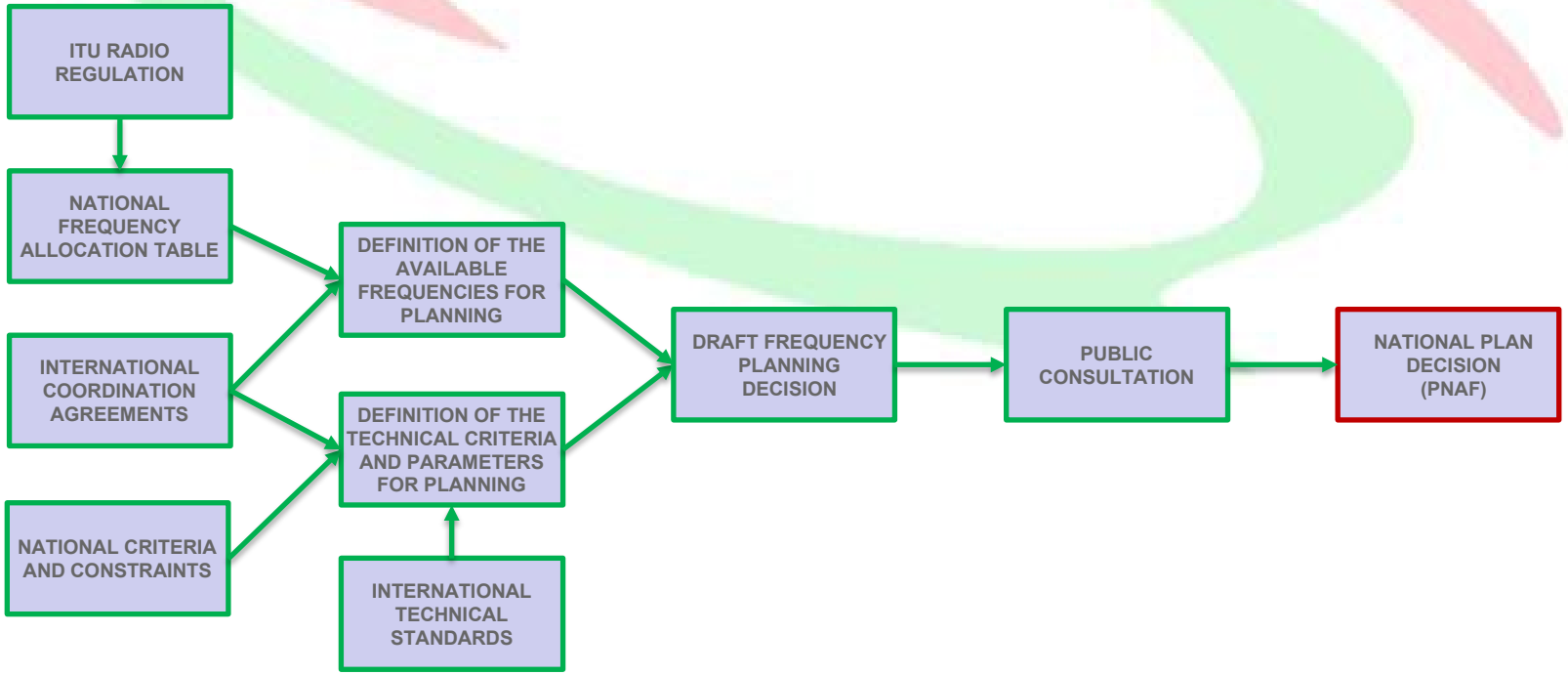
Frequency planning process



Public consultation

- Once the feasibility verification is succesfully completed, a Draft Plan is prepared
- The Draft Plan is mandatorily submitted to public consultation
  - In particular, the position is specifically asked from
    - The Public Broadcasting Service operator (PBS), in Italy RAI and (for an autonomous province) RAS
    - The Broadcasting Associations, both local and national
  - Single network operators can participate in the consultation
  - As with any consultation, the results are carefully assessed by Agcom, and can lead to modifications both of planning parameters and even to the Draft Plan
  - Any decision should be duly motivated in the final decision
  - In case of the last PNAF-DAB the consultation has highlighted the fact that today the most prevailing way of DAB+ service consumption is onboard vehicles, and this led to adopt planning parameters targeted to mobile receptions (instead of for example *portable outdoor*)
  - Other sligth modifications have been accomodated (see preamble of the final decision n. 286/22/CONS of July 2022)

Frequency planning process

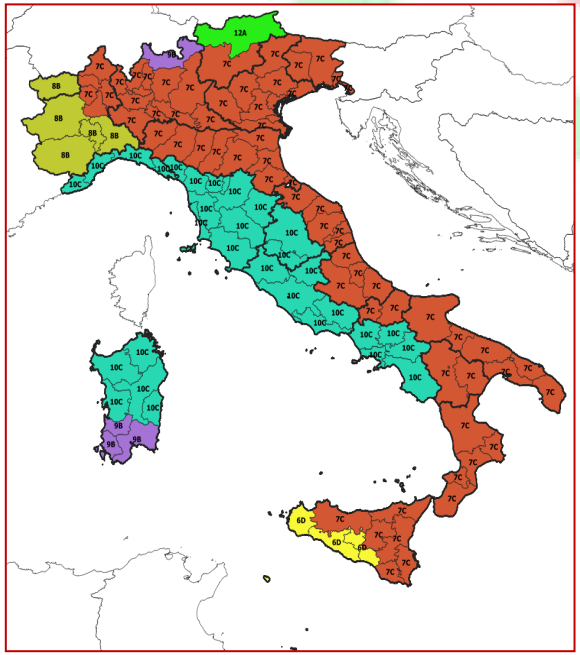


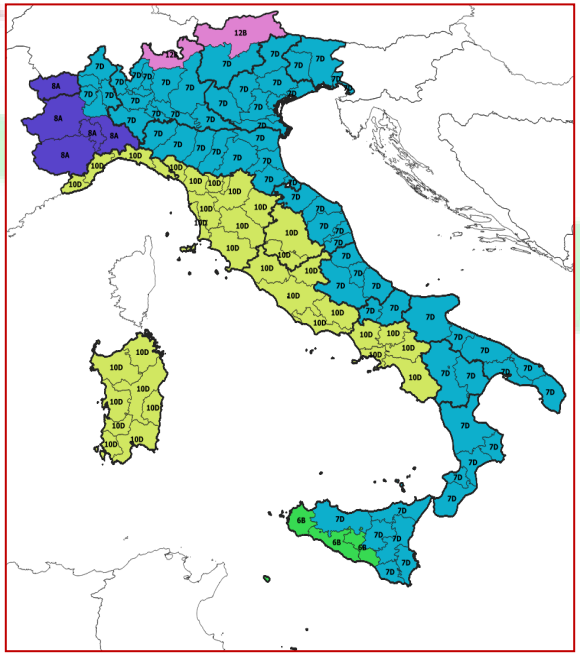
Final Plan adoption

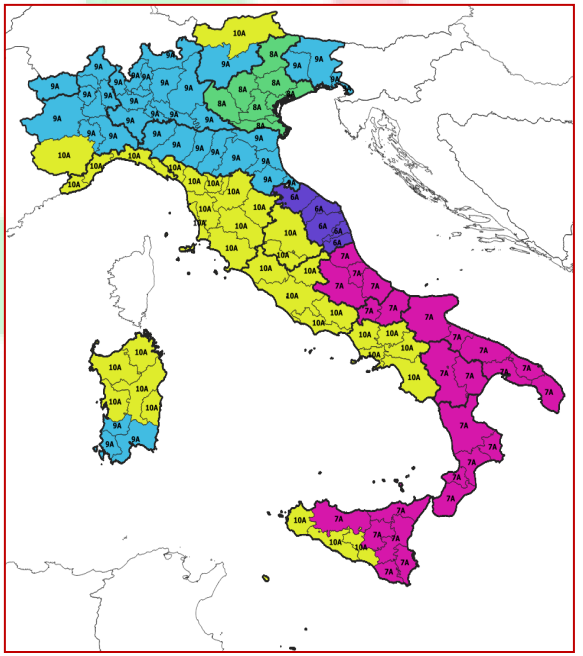
- After the preparation process is over, the final Plan is formally adopted with an Agcom Decision
- The last Italian DAB+ frequency plan was finally approved with Decision n. 286/22/CONS of 27 July 2022
- Planning outcome
  - N. 3 national networks with 1-SFN structure in macro-areas (3 main macroareas for the first 2 networks and 6 main for the third)
  - N. 54 local networks with regional structure coverage (slightly less than 21 regions x 3)
  - N. 36 local networks with sub-regional structure coverage
  - All planned networks are able to reach at least 70% of the population in their service area with the foreseen reception quality (CovProb>=95%)

Final DAB+ Plan (decision n. 286/22/CONS)

Mapping of the planned frequencies to the national networks

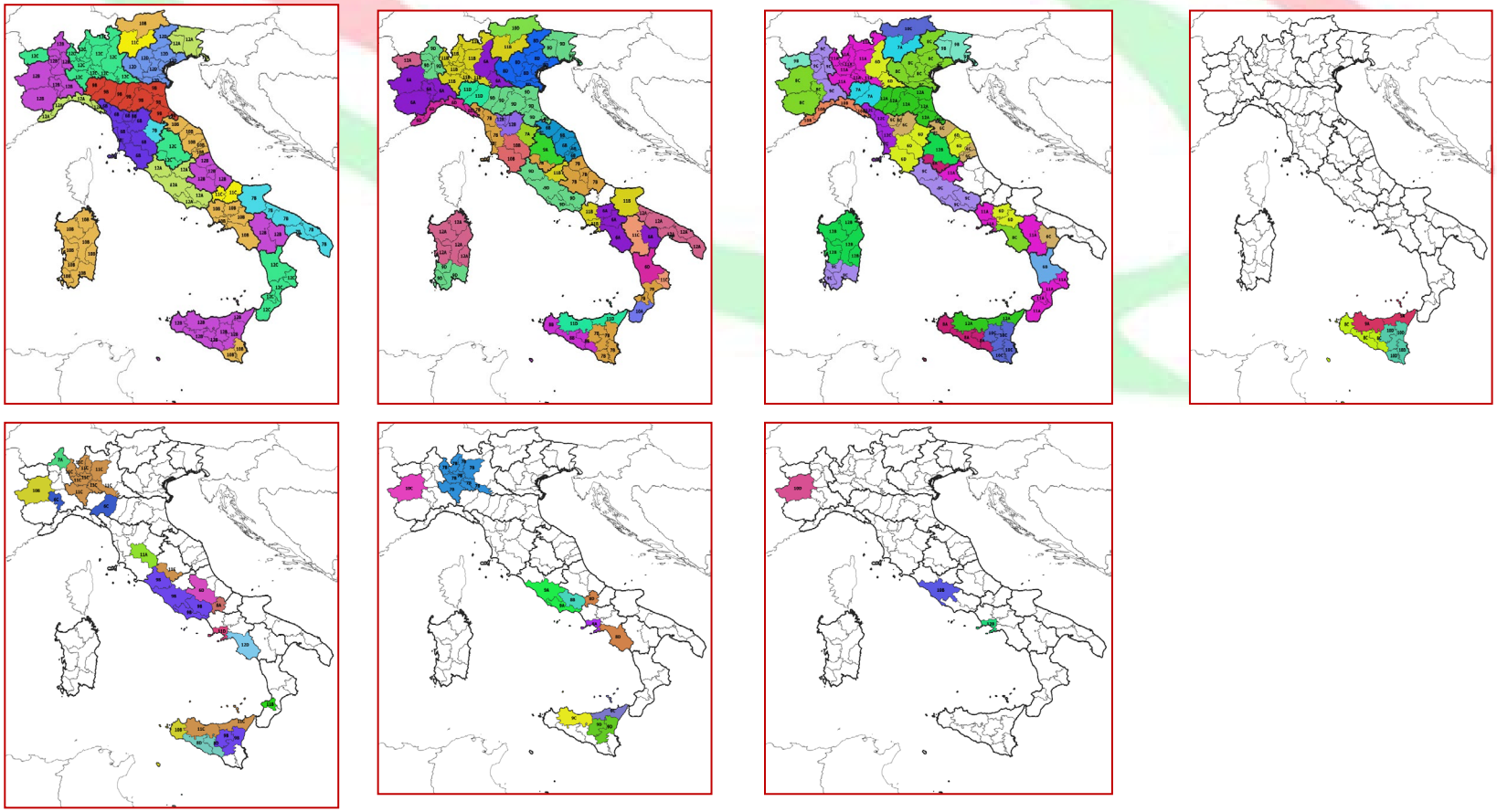






Final DAB+ Plan (decision n. 286/22/CONS)

Mapping of the planned frequencies to the local networks



Some final considerations

- Over the years AGCOM has always supported the development of the DAB+ market
- We had to wait until the TV switch over was completed after the 700 MHz band refarming in order to have enough resources to plan
- Two highlights:
  1) Consortium market model: in order to accommodate the great access demand to networks, AGCOM has introduced the consortium market model in its DAB Regulation. Excluding the PBS (i.e. RAI), the other networks, national and local, have been (in the old provisional Plan) and will be (under the new) assigned to consortia of national or local operators
  2) PNAF-DAB "density": the AGCOM Plan has been developed to offer a high number of networks not only for the sake of efficient use of spectrum, but also to extend the overall transport capacity. Considering the overcrowded FM band, the AGCOM DAB+ Plan offers a transport capacity virtually capable of satisfying the entire or at least most of the current analogue FM radio market
- Now the process of granting the rights of use of frequencies for the new networks is on-going, under the responsibility of the Ministry, as shown
- Regulator frequency planning is a very different job compared to Broadcaster network planning. Both are conditioned by the specific broadcast technical standard and practice but:
  - from the Regulator's perspective, the main inputs are the legal and regulatory constraints regarding efficient use of spectrum and safeguard of pluralism and competition, with the (scarce) radio resources internationally available for planning

Thank you for your attention