# Planning and administering digital broadcasting

**ITU/ASBU Workshop on Frequency Planning and Digital Transmission**

Damascus, Syria
22-25 November 2004

ATDI

# About ATDI

ATDI provides software and services in radio communications

- Radio network planning & management
- Regulatory and control software
- Spectrum management
- Digital cartography
- Communication electronic warfare

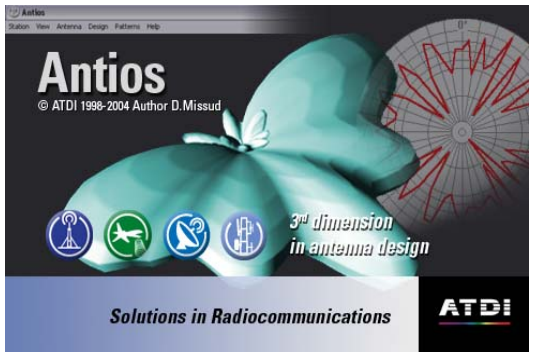
Main market

- Telecom operators
- Regulators
- Telecom manufacturer
- Engineering
- Military forces
- GIS, digital maps


**The most comprehensive software for any kind of radio network planning : mobile, PMP, microwave links**

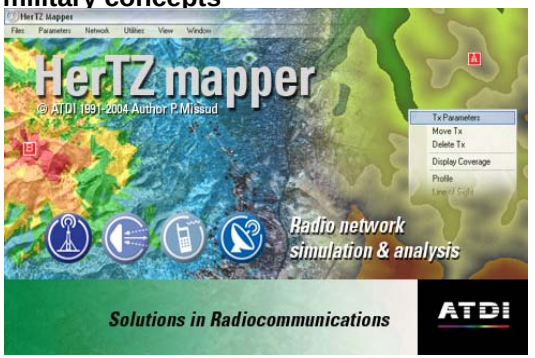

**The most complete and efficient solution dedicated to regulators for national and international spectrum management**


**The Infrastructure and tactical electronic warfare radio network planning tool the most adapted for new military concepts**




**Antios is a 3D software system for the design of antennas and antenna systems**


**ICS Map Server is an advanced software system designed to manufacture and manage digital cartography.**




**HerTZ Mapper is a state-of-the-art radio communication network planning tool for VHF, UHF and SHF, that is flexible enough to fully answer the needs of radio system designers.**

# Administrating and planning Digital Broadcasting


ATDI

*Solutions in Radiocommunications*

# Foreseeable Trends

Digital Broadcast will be motivated by:

- Its expected popularity, due to
  - lower cost and better management
  - More contents to broadcast: Up to 6 Analogue channels are multiplexed in a single Digital Multiplex requiring lower power
- Its expected necessity, due to
  - Extensive programs and high popular demands of content diversity
  - Consideration of Neighboring Digital Broadcast that would occupying part of the national spectrum

# Expected Status quo

Digital Broadcasting

- may require national legislation for regulating this type of service
- may require liberalization to allow private investments to implement DTT when or if such a condition is needed

# Milestones in digital organisation (1)

- Eureca 147 standard (ETS 300 401);
  standardization completed in late ’80s
- CEPT preparations for frequency planning in early ’90s
  - search for suitable frequency bands
  - development of planning method
  - preparation of national requirements
- CEPT Planning meeting in Wiesbaden, Germany in July 1995
  - Main objective: allotment plan for introduction of T-DAB
  - Special Arrangement (rules for modifications to the allotment plan and conversion of the allotments into assignments)
  - Allotment plan

# Milestones in digital organisation (2)

- First revision to the Special Arrangement, Bonn, November 1996
  - Refined method for conversion of an allotment into assignments as well as co-ordination and notification procedure
- Second revision to the Special Arrangement, Maastricht, June 2002
  - Planning for additional allotments in 1.5 GHz band
  - Revised Wiesbaden Special Arrangement reduced to bands I, II and III
  - New Maastricht Special Arrangement for 1.5 GHz band

# Milestones in digital organisation (3)

- CEPT meeting in Chester, UK in July 1997
  - Multilateral Coordination Arrangement relating to Technical criteria, Co-orindation principles and Procedures for the introduction of DVB-T
  - Additional to Stockholm Agreement ’61;
  - No plan for DVB-T attached; updated Stockholm ’61 plan wasrelevant
  - Frequency bands: 174-230 MHz and 470-862 MHz
  - Technical criteria based on ETS 300 744 for DVB
  - Co-operation between CEPT, EBU, ERO and Administrations
  - 35 countries signed the Agreement

# Chester´97 follow-on (1)

## Successful introduction of DVB-T transmission

- commercial services in 7 European countries
- test transmissions in 20 countries (as of June 2003)
- different approaches choosen by different countries

## The reference interference situation for analogue TV was established in May 2002 following extensive co-ordination, data processing and multiple calculation exercises

- more than 88000 analogue TV stations were included
- co-operation between CEPT/FMPT24, EBU, ERO and different administrations
- bilateral co-ordination continues

# Chester´97 follow-on (2)

- Need for the planning conference
  - Ch97 and St61 cannot not provide solution for the all-digital situation:
    - sub-optimal with respect to frequency efficiency,
    - reception conditions and
    - network economy
- Experience was used to prepare the RRC-04/05

# What was learned during planning

- Allotment approach provides for efficient planning;
- additional work is required after the planning meeting (implementation phase)
- Computer based plan synthesis lead to the creation of
  - A plan of optimisation based on the agreed criteria
  - Different means to achieve equitable access

# Further findings

- Protection of other services is a major issue to be considered when planning broadcasting.
- Electronic data format used throughout the whole process allowed rapid data validation and efficient utilisation of data resources

In Europe, Co-operation between CEPT, EBU, ERO and Administrations was essential for successful planing

# Advantages of DTT Broadcasting

- Flexible approach ( circa  120 possibilities)
- SFN / MFN or a mixture of Both
- Mobile reception
- Possible use of TABO channels
- Robust to multipath effects
- Similarity with DVB-S, DVB-C
- Can use popular and inexpensive type of set-top box

# Planning principles - general

- Planning process is first of all based on administrations' requirements that protects or guarantees
  - Existing analogue stations and assignment
  - Existing border agreements with neighbouring countries
  - National coverage requirement
- Equitable access to frequency resources that takes into account technical and economic constraints
- Use of the minimum number of channels to satisfy requirements

# Planning principles - general

- Proposed digital allotments/assignments open to bilateral or multilateral negotiation between administrations concerned
- Based on results of planning exercises incompatibilities should be resolved by bi/multilateral discussions prior to Second Session
- Planning provisions for countries not present
- No account to be taken of low power digital assignments in the planning process – these can be entered later

# Requirement for Administrative planning

- Each administration is required to:
  - decide on the compatibility of digital plan with existing services in its own country and
  - indicate which existing and planned stations should be protected

Each administration needs to carry out a number of exercises to determine the above and prepare for the next meeting by February 2005

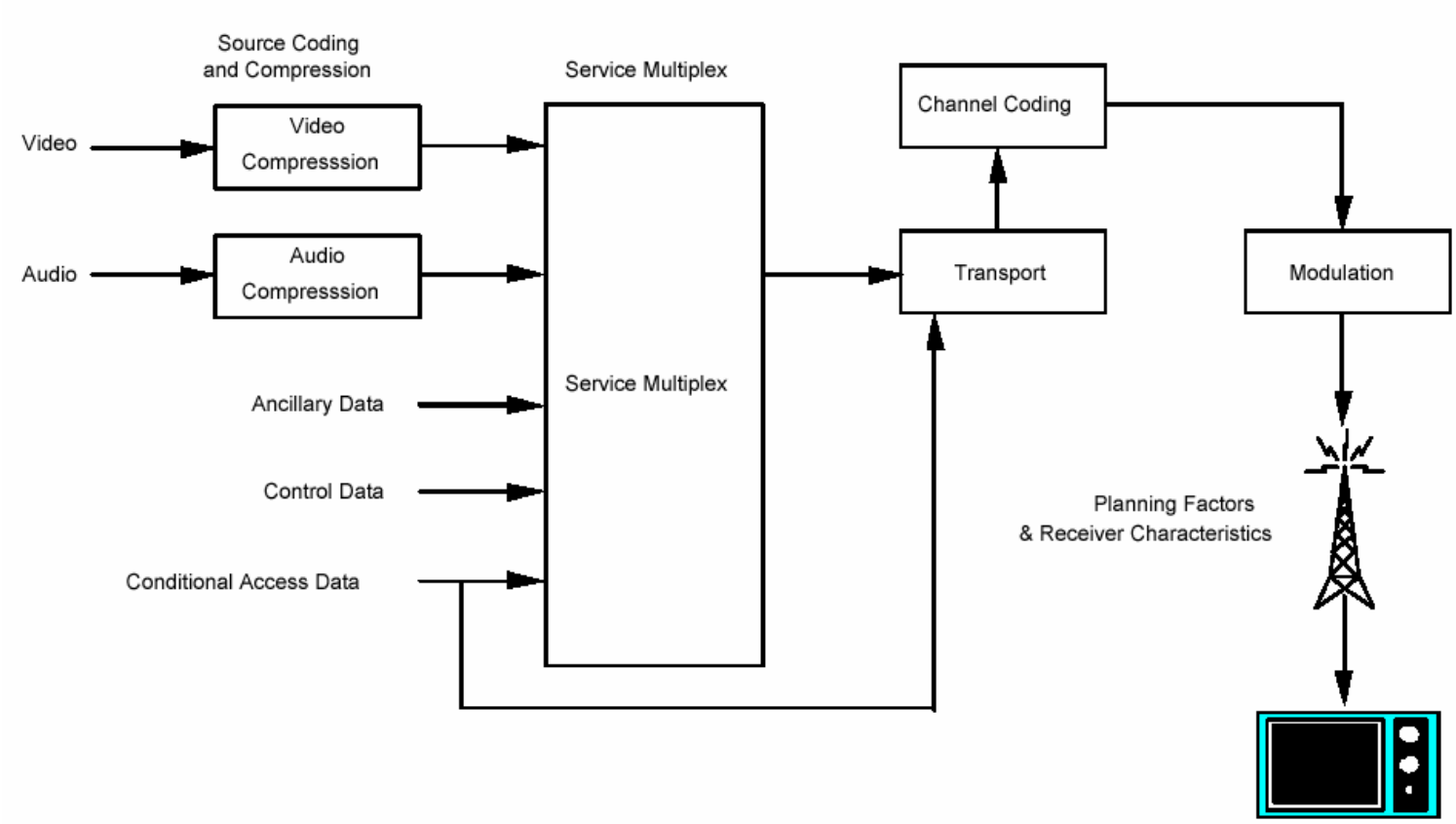
# Building up the Administrative requirement

Digital Broadcasting requirements

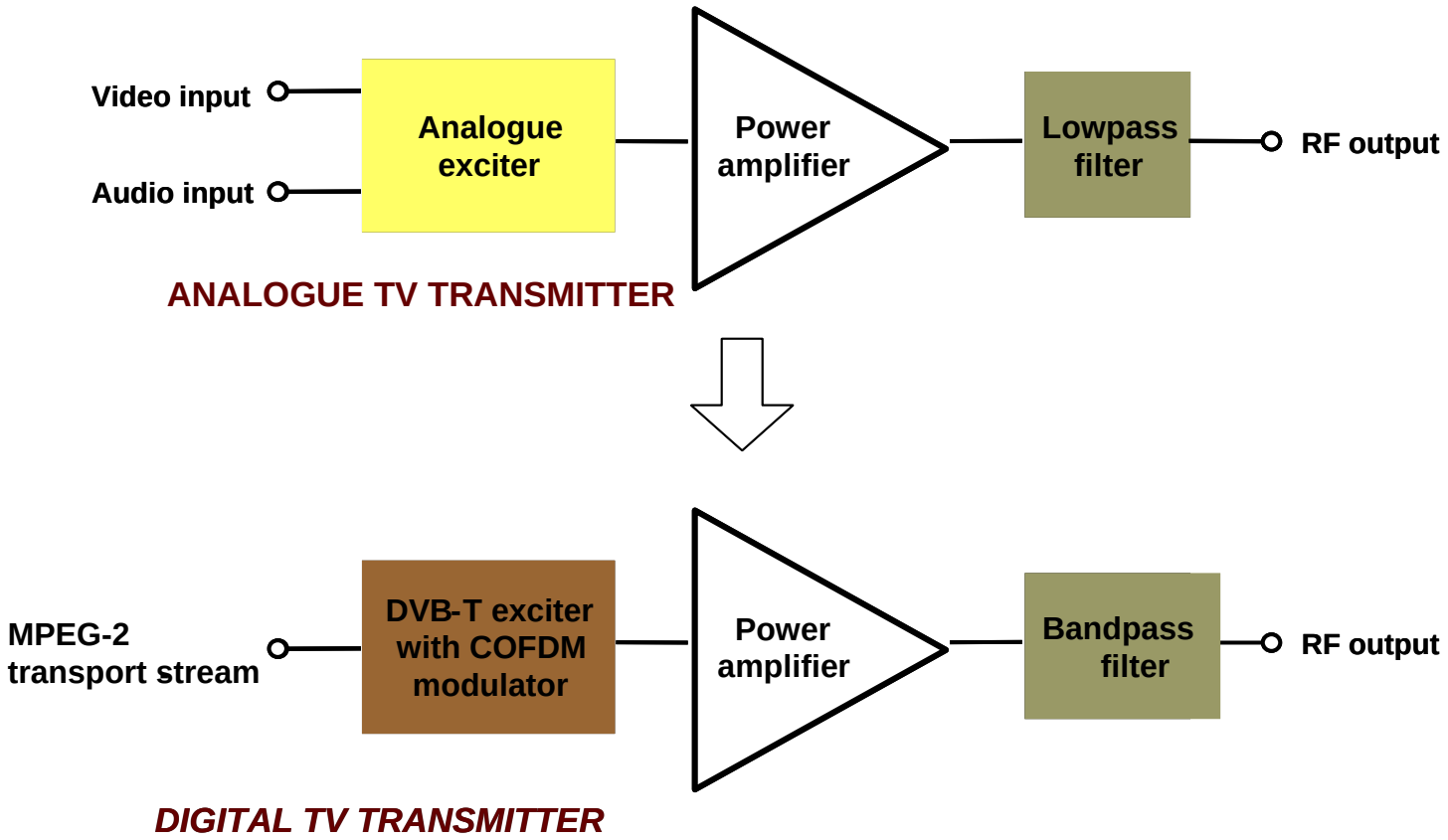
Protection requirements

Choosing the appropriate model

# Structure of DTT Broadcasting



# Analogue versus DTT Broadcasting



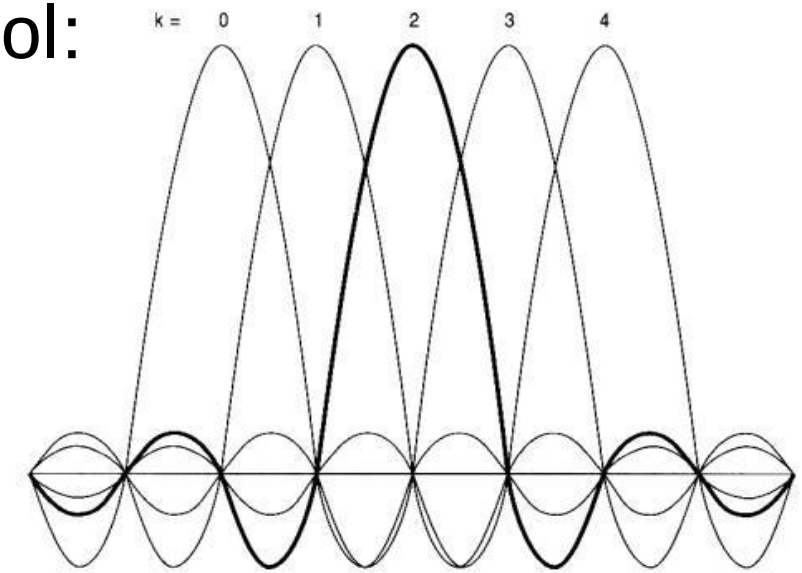
# Coded Orthogonal Frequency Division Multiplex

Number of carriers per symbol:

- 2k - 1705
- 8k – 6817

Modulation:

- QPSK
- 16 QAM
  (uniform or non-uniform)
- 64 QAM
  (uniform or non-uniform)



# Guard interval

$$T_s = T_u + T_g$$

$$T_g = 1/4,\ 1/8,\ 1/16 \text{ or } 1/32\ T_g$$

- $T_s$ = symbol duration
- $T_u$ = usefull symbol duration
- $T_g$ = guard interval

Some carriers are pilots used for synchronisation, transmission of parameters and signal recovery purposes

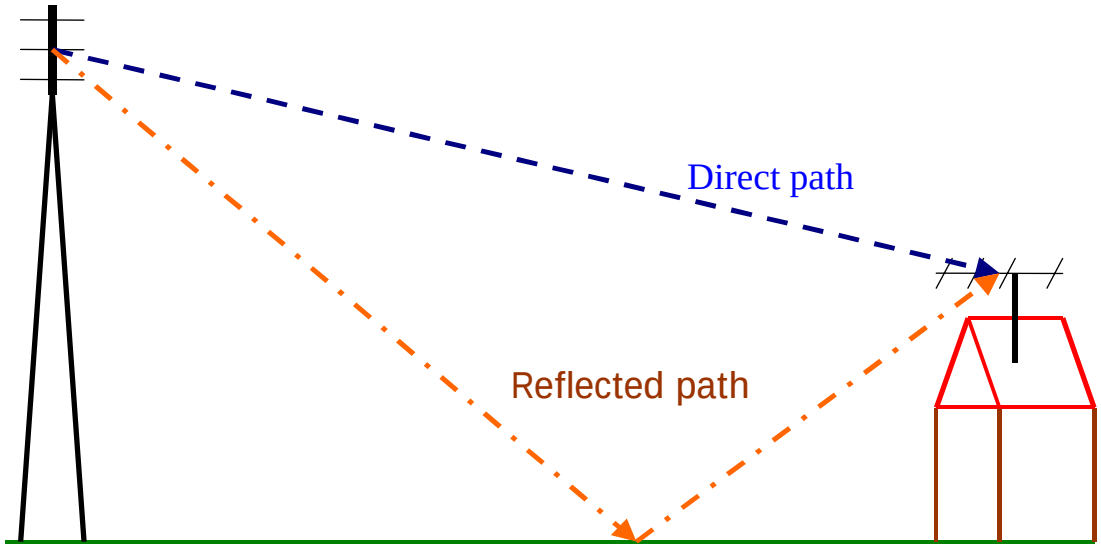
# Forward Error Correction

Inherited from the Satellite Digital Transmission

- Outer code:
  - Reed Solomon (204, 188, 16)
- Interleaving
- Inner code:
  - convolutional with Viterbi soft decision decoding.
- Coding rates:
  - 1/2 - 2/3 – 3/4 - 5/6 - 7/8

# Multi Path propagation

- Taking Advantage of reflections



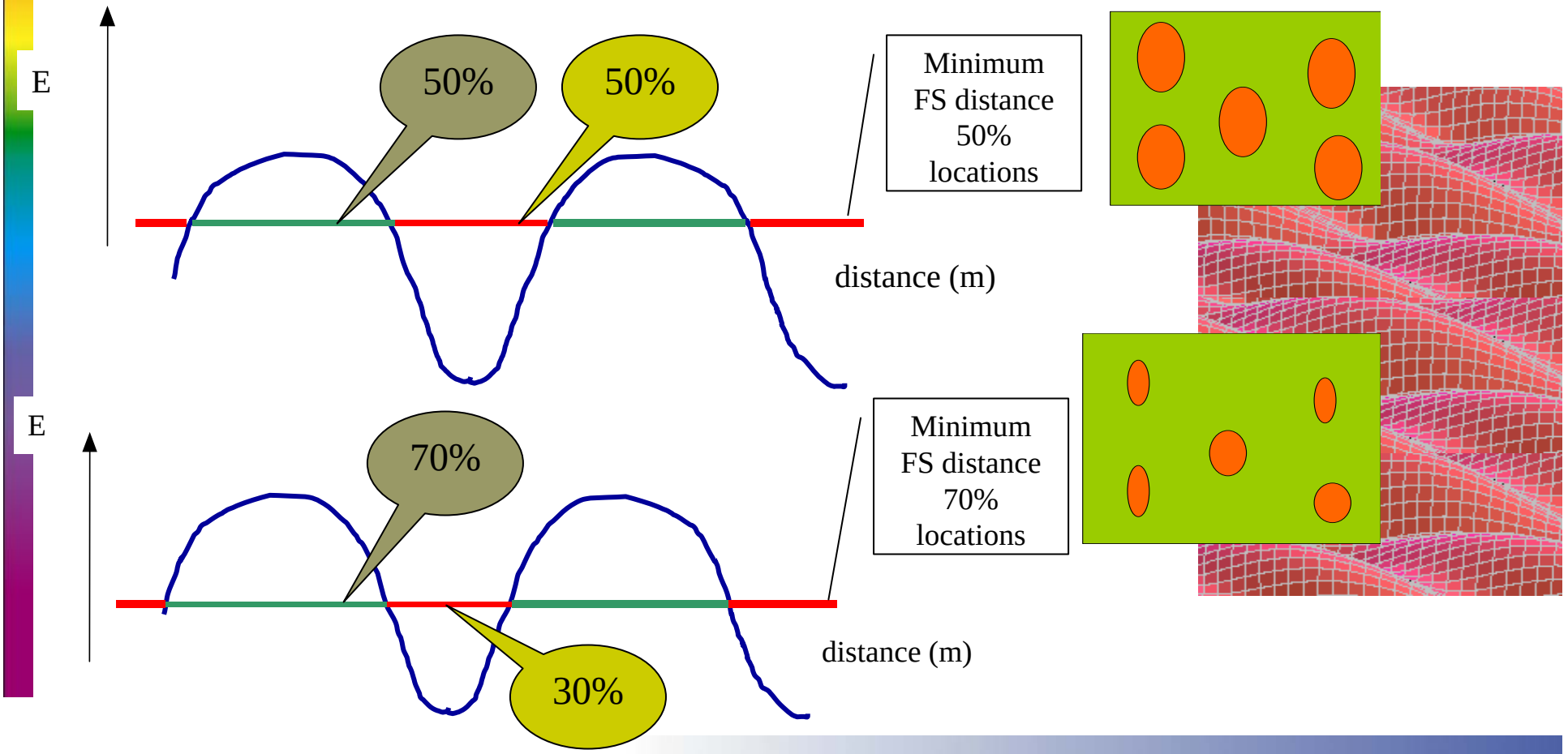
# Reception modes

- Fixed reception
- Class A portable reception (outdoor)
- Class B portable reception (ground floor indoor)
- Mobile reception (moving with such speed that Doppler effect appears)

# Coverage

- Location (0,5 x 0,5)m covered for 99% of the time
- Small area (100 x 100) m
  - Good coverage for > 95% of locations
  - Acceptable for > 70% of locations
- Coverage area – sum of individual small areas

# Minimum field strength distribution

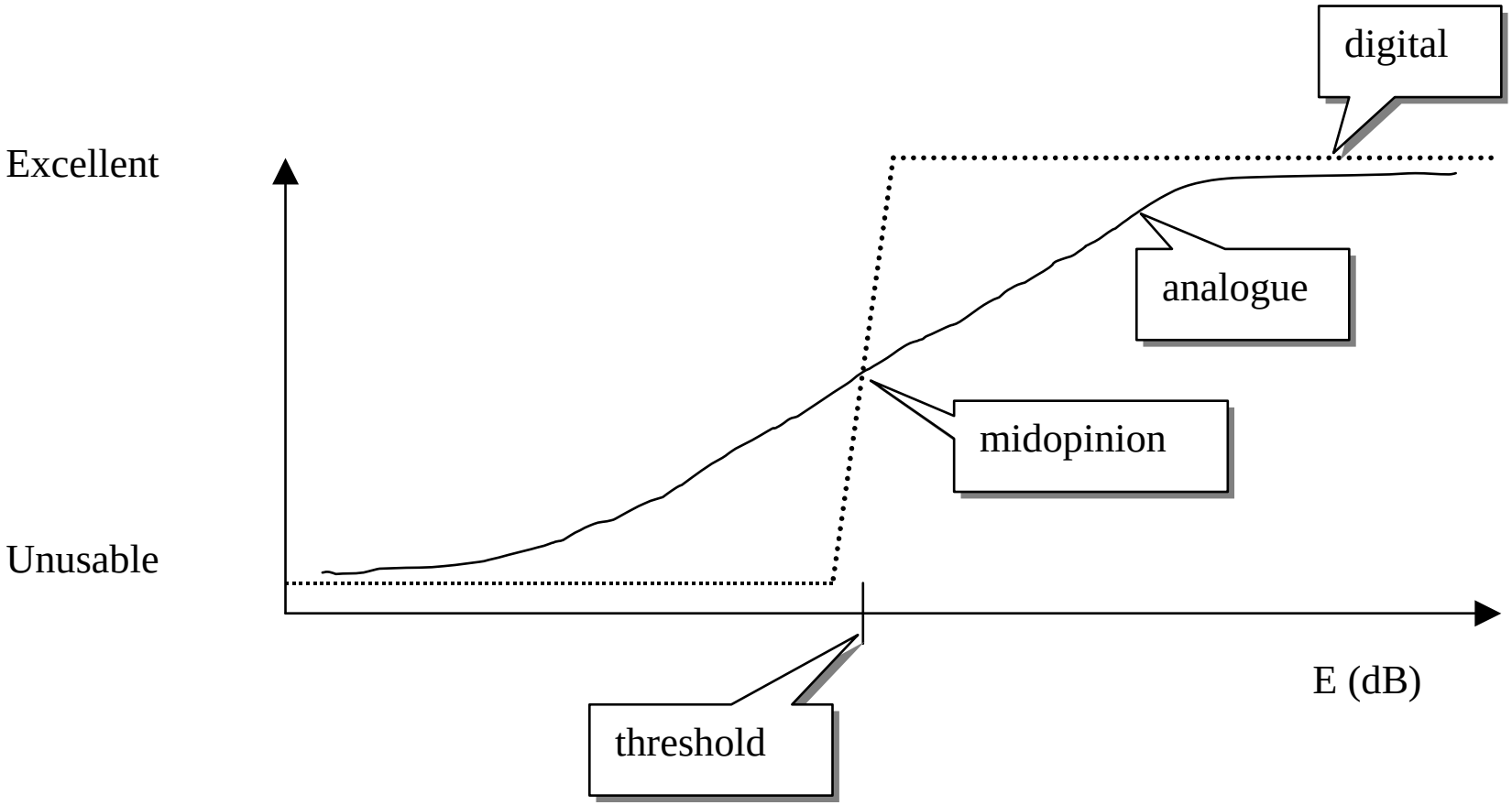


# Limit value for planning

- Analogue: S/N = 30 dB (unweighted)
- Digital: BER $2x10^{-4}$ (Quasi Error Free)

- - 3 dB difference means **½ grade** on quality scale in analogue picture,
- This leads to **no picture in digital broadcasting**

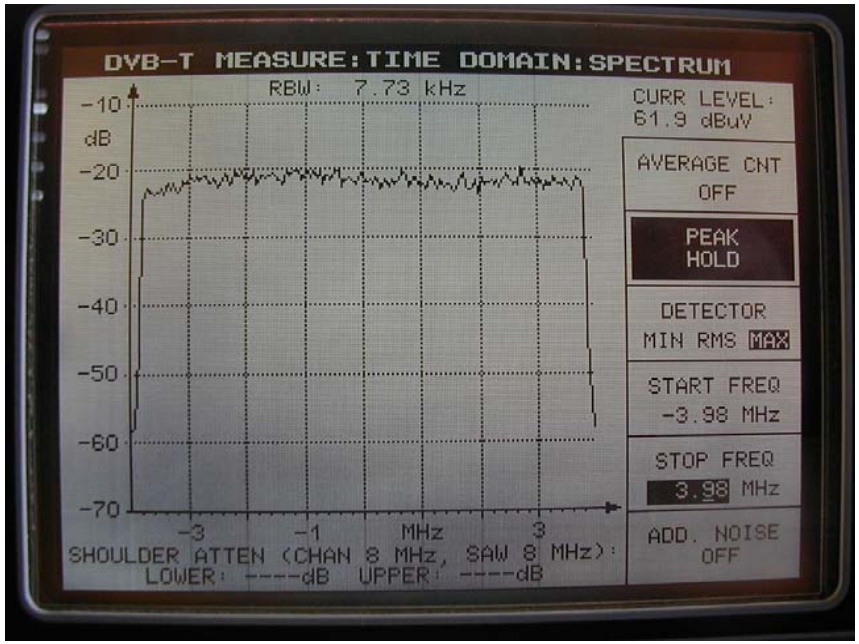
# Cut-off characteristics



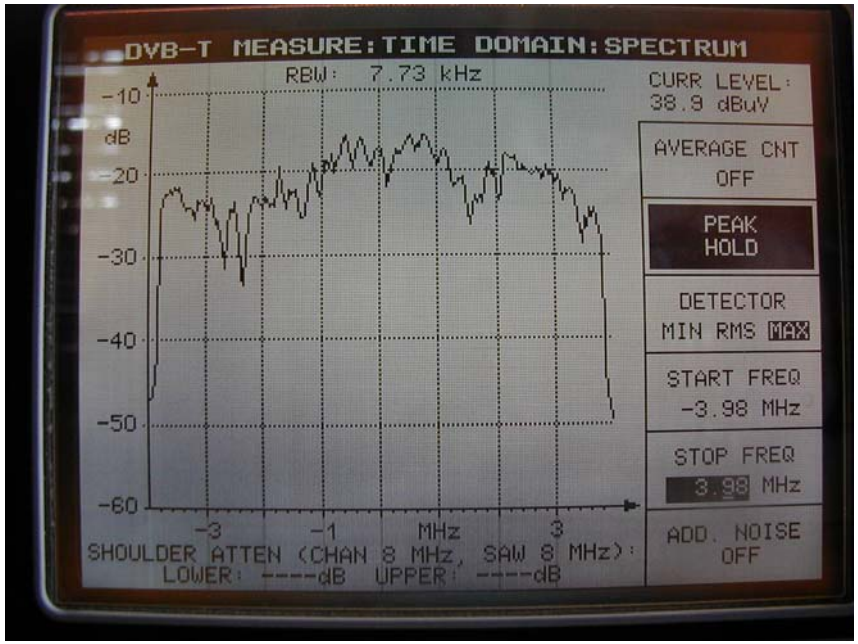
# Transmission Channels

- **Gaussian Channel** – direct sight, no multipath ($\sigma < 1$dB)
- **Rice Channel** ($1 < \sigma < 3$ dB) – stationary reception using directional antenna
- **Rayleigh Channel** ($\sigma > 3$ dB) – portable reception using omnidirectional antenna

# Example of Transmission Channels




Ricean Channel




Rayleigh Channel

# Required C/N

| Modu-lation | Code rate | Required C/N for BER = $2 \times 10^{-4}$ after Viterbi QEF after Reed-Solomon: Gaussian channel | Ricean channel ($F_1$) | Rayleigh channel ($P_1$) | Bitrate (Mbit/s): $\Delta/T_U$ = 1/4 | $\Delta/T_U$ = 1/8 | $\Delta/T_U$ = 1/16 | $\Delta/T_U$ = 1/32 |
|---|---|---|---|---|---|---|---|---|
| QPSK | 1/2 | 3,1 | 3,6 | 5,4 | 4,98 | 5,53 | 5,85 | 6,03 |
| QPSK | 2/3 | 4,9 | 5,7 | 8,4 | 6,64 | 7,37 | 7,81 | 8,04 |
| QPSK | 3/4 | 5,9 | 6,8 | 10,7 | 7,46 | 8,29 | 8,78 | 9,05 |
| QPSK | 5/6 | 6,9 | 8,0 | 13,1 | 8,29 | 9,22 | 9,76 | 10,05 |
| QPSK | 7/8 | 7,7 | 8,7 | 16,3 | 8,71 | 9,68 | 10,25 | 10,56 |
| 16-QAM | 1/2 | 8,8 | 9,6 | 11,2 | 9,95 | 11,06 | 11,71 | 12,06 |
| 16-QAM | 2/3 | 11,1 | 11,6 | 14,2 | 13,27 | 14,75 | 15,61 | 16,09 |
| 16-QAM | 3/4 | 12,5 | 13,0 | 16,7 | 14,93 | 16,59 | 17,56 | 18,10 |
| 16-QAM | 5/6 | 13,5 | 14,4 | 19,3 | 16,59 | 18,43 | 19,52 | 20,11 |
| 16-QAM | 7/8 | 13,9 | 15,0 | 22,8 | 17,42 | 19,35 | 20,49 | 21,11 |
| 64-QAM | 1/2 | 14,4 | 14,7 | 16,0 | 14,93 | 16,59 | 17,56 | 18,10 |
| 64-QAM | 2/3 | 16,5 | 17,1 | 19,3 | 19,91 | 22,12 | 23,42 | 24,13 |
| 64-QAM | 3/4 | 18,0 | 18,6 | 21,7 | 22,39 | 24,88 | 26,35 | 27,14 |
| 64-QAM | 5/6 | 19,3 | 20,0 | 25,3 | 24,88 | 27,65 | 29,27 | 30,16 |
| 64-QAM | 7/8 | 20,1 | 21,0 | 27,9 | 26,13 | 29,03 | 30,74 | 31,67 |

# Planning requirements

- Minimum field strengths

Fixed reception
64 QAM 2/3
Rice channel

| BAND | III | IV | V |
|---|---|---|---|
| **Analogue** | **55** | **65** | **70** |
| **Digital** | | | |
| 70% locations | **39** | **44** | **48** |
| 95% locations | **45** | **50** | **54** |

Portable outside reception
64 QAM 2/3
Rayleigh channel

| BAND | III | IV | V |
|---|---|---|---|
| **Analogue** | **55** | **65** | **70** |
| **Digital** | | | |
| 70% locations | **59** | **65** | **69** |
| 95% locations | **64** | **71** | **75** |

# Planning requirements

- Minimum field strengths

Portable inside reception
64 QAM 2/3
Rayleigh channel

| BAND | III | IV | V |
|---|---|---|---|
| **Analogue** | **55** | **65** | **70** |
| **Digital** | | | |
| 70% locations | **66** | **73** | **77** |
| 95% locations | **73** | **83** | **87** |

Portable outside reception
64 QAM 2/3
Rayleigh channel

| BAND | III | IV | V |
|---|---|---|---|
| **Analogue** | **55** | **65** | **70** |
| **Digital** | | | |
| 70% locations | **59** | **66** | **70** |
| 95% locations | **68** | **76** | **80** |

# Planning requirements

- Minimum field strengths

Mobile reception - Typical urban
16 QAM 1/2 non diversity

| **BAND** | III | IV | V |
|---|---|---|---|
| **Analogue** | **55** | **65** | **70** |
| Max.speed | 254 | 102 | 64 |
| Locations 70% | **58** | **65** | **69** |
| Locations 95% | **64** | **71** | **77** |

Mobile reception - Typical urban
antenna diversity

| BAND | III | IV | V |
|---|---|---|---|
| **Analogue** | **55** | **65** | **70** |
| Max.speed | 508 | 203 | 127 |
| Locations 70% | **52** | **59** | **63** |
| Locations 95% | **58** | **65** | **69** |

# Co-channel Interference

| **ANALOGUE**<br>Offset 8/12 | Norm.offset<br>500 Hz | Prec. offset<br>1 Hz |
|---|---|---|
| Tropospheric | 30 | 22 |
| Continiuous | 40 | 27 |
| **DIGITAL** | Rice | Rayleigh |
| 64 QAM 2/3 | 20 | 23 |
| 16 QAM 1/2 | 11 | 13 |
| ATSC | 15 (19) | 15 (19) |

# Assignment / Allotment

- Terrestrial television planning has been by way of assignment conferences (ST61, GE89, etc...)
- Planning may be based on

  Lattice based
  - This a systematic and geographically regular distribution of frequency resources over an area

  Lattice independent
  - This is a pseudo-random but spectrum utilization efficient distribution of frequency resources over an area
- Planning, since Wiesbaden 95, require a new concept defined as Allotment

# Lattice-based methods

Lattice based methods assume:

- Geometrically regular lattices, linear channel-distribution schemes
- All transmitters are identical, their powers and antenna heights being the same
- Antenna radiation patterns are omni-directional in the horizontal plane
- Radio wave propagation losses are not a function of propagation direction and frequency

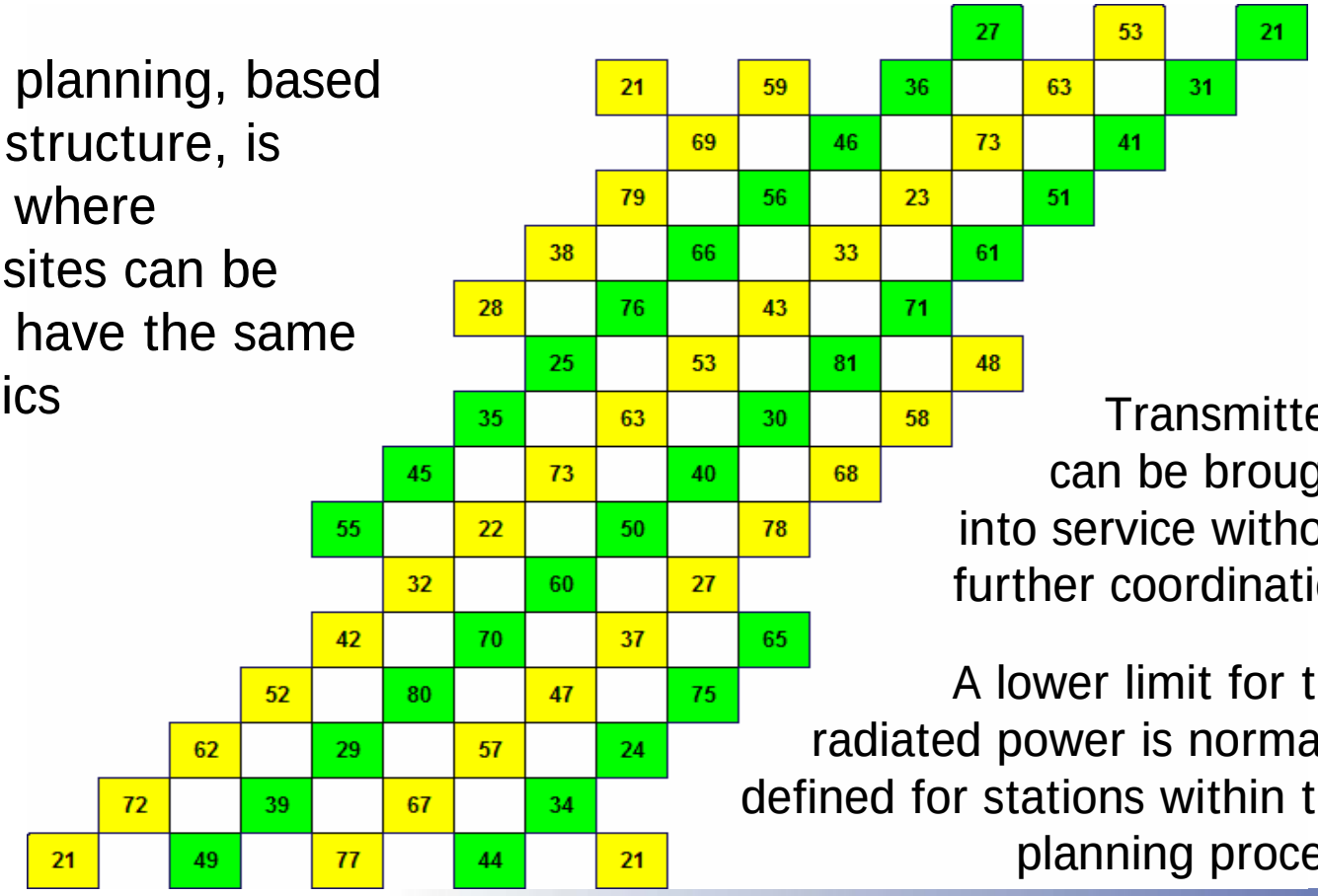
# Application of Lattice based method

Lattice based methods have been applied with success for past planning/re-planning of AM or FM sound or televisions services where:

- Empirical methods were difficult to implement
- When some uniformity of standards exists for the services to be planned
- There is freedom in assigning any frequency to any transmitter

# Planning approach: Using Assignments

Assignment planning, based on a lattice structure, is appropriate where transmitter sites can be assumed to have the same characteristics



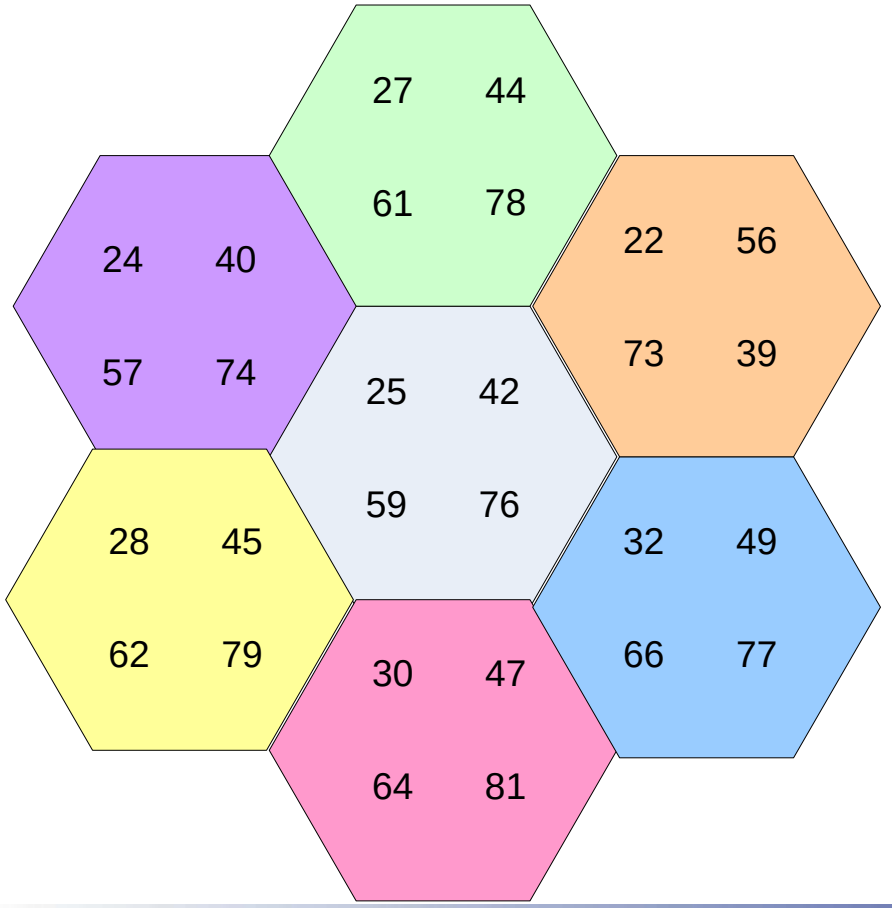

Transmitters can be brought into service without further coordination

A lower limit for the radiated power is normally defined for stations within the planning process

# Assigning channels

In a lattice structure, transmitters sites are placed to coexist with other transmitters using non interfering channels

The assignment plan provides a frequency for each station, at the completion of the planning process, the locations and characteristics of the transmitters are known



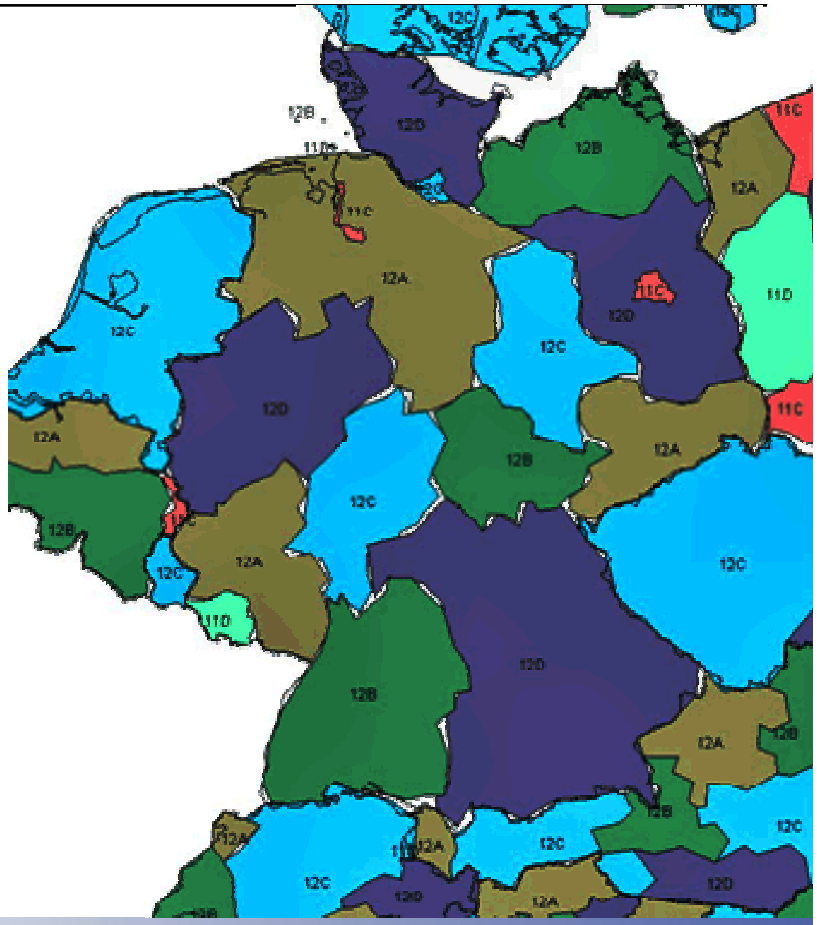
# Lattice-independent methods

- makes no assumption of the network uniformity
- can be a significant advantage where:
  - Coverage requirements start from any approximation to a regular lattice
    - with useful for a mixture of large and small areas requiring different programmes, and
    - in areas where several countries meet and each has adopted a different coverage philosophy
  - A set of assignments needs to be added into an existing planned broadcasting situation, or there are analogue stations in the same part of the spectrum
- allow a more-or-less continuous process of transition from analogue only
- represents a close approach to optimum use of the spectrum when coverage areas are non-uniform

# Planning approach: Using Allotments

- Nothing is known of the actual location of the transmitter sites, or characteristics to be used

- The parameters required are a definition of the area to be covered, the channel and the interference potential of the allotment



# Planning Allotments

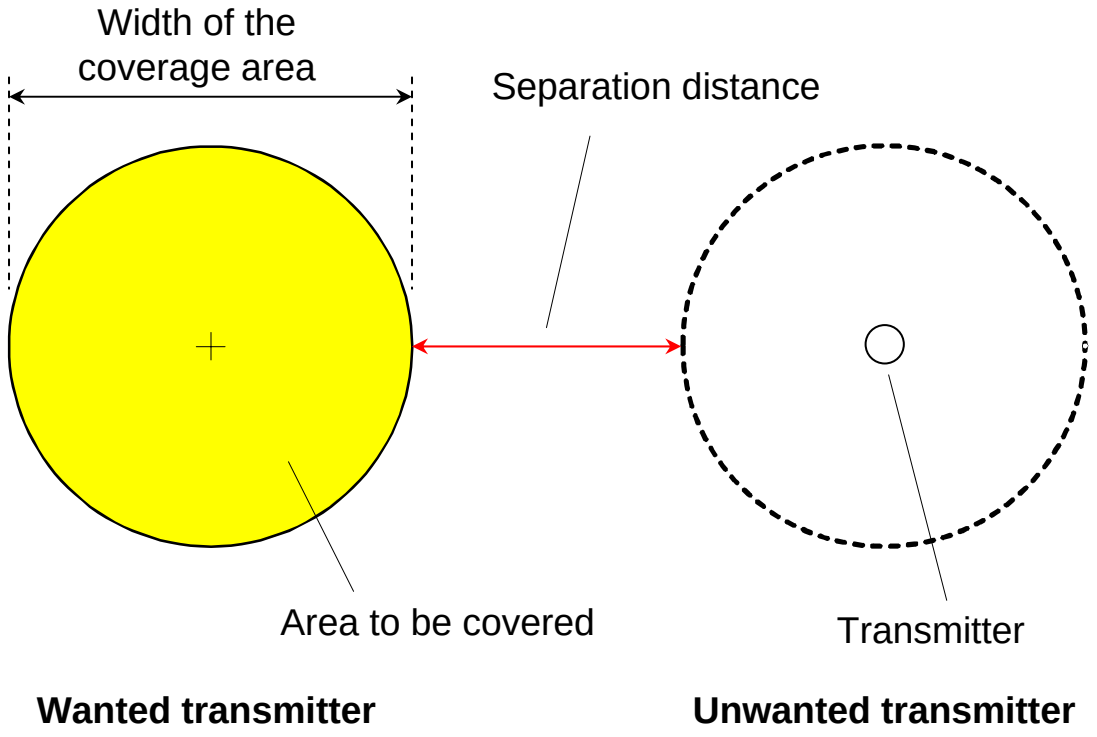
In order to carry out planning it is necessary to

- define reference transmission conditions
- calculate potential interference and
- facilitate compatibility calculations

The allotment plan provides
frequencies
to be used in particular areas without
specifying the stations to which the
frequencies are assigned

# Allotment planning: reference networks

- Reference networks are required to assess the outgoing interference potential with particular reference to:
  - calculating the compatibility between allotment areas – including separation distance
  - the generation of a set of calculation test points for the later conversion of allotments into assignments



# Assignment vs. allotment planning

- Assignment planning is preferable
  - Where transmitter infrastructure is known
  - In the case of MFN or small SFN planning
- Allotment planning is preferable
  - When the transmitter infrastructure is not known
  - When channels are available for planning DVB-T services which are required to cover the whole of a larger area
  - If great potential for flexibility in terms of the implementation of transmitter networks within the Plan is desired
  - If portable reception is a prime requirement

# Protection between various services

- Analogue television
  - Need to address conditions for protection of existing stations
  - Administrations must consider existing and planned stations to protect
  - Administrations should ensure that their entries in ST61, GE89 and Master Register reflect the actual co-ordinated situation
- Digital broadcasting
  - Need to address conditions for digital terrestrial television broadcasting currently recorded in the Master Register with favourable findings
- Other services
  - Need to consider conditions for other services sharing the frequency bands 174 to 230 MHz and 470 to 862 MHz

# Handling Allotments and Assignments

Creating an Allotment

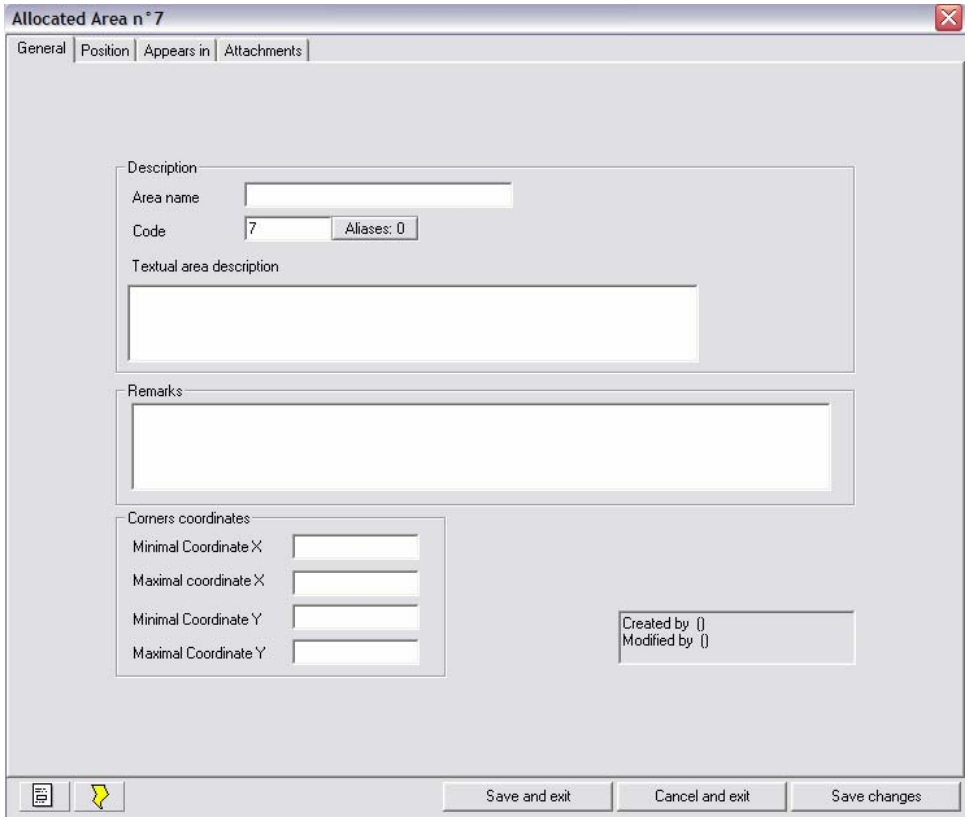
Creating channeling plans

Creating assignment in Analogue or Digital Broadcast

Recording a station parameter

# Defining an allotment

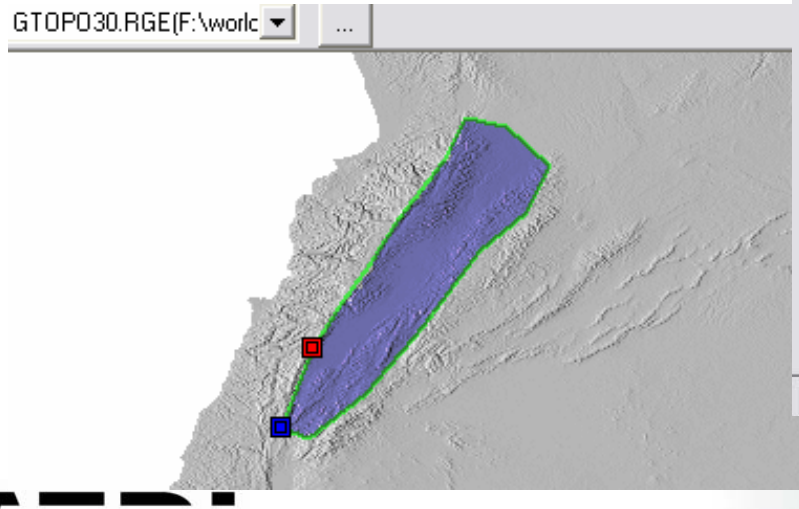
- Provide an area name / code
- Each allotment is given
  - A textual area description
  - Remarks
  - Corner coordinates

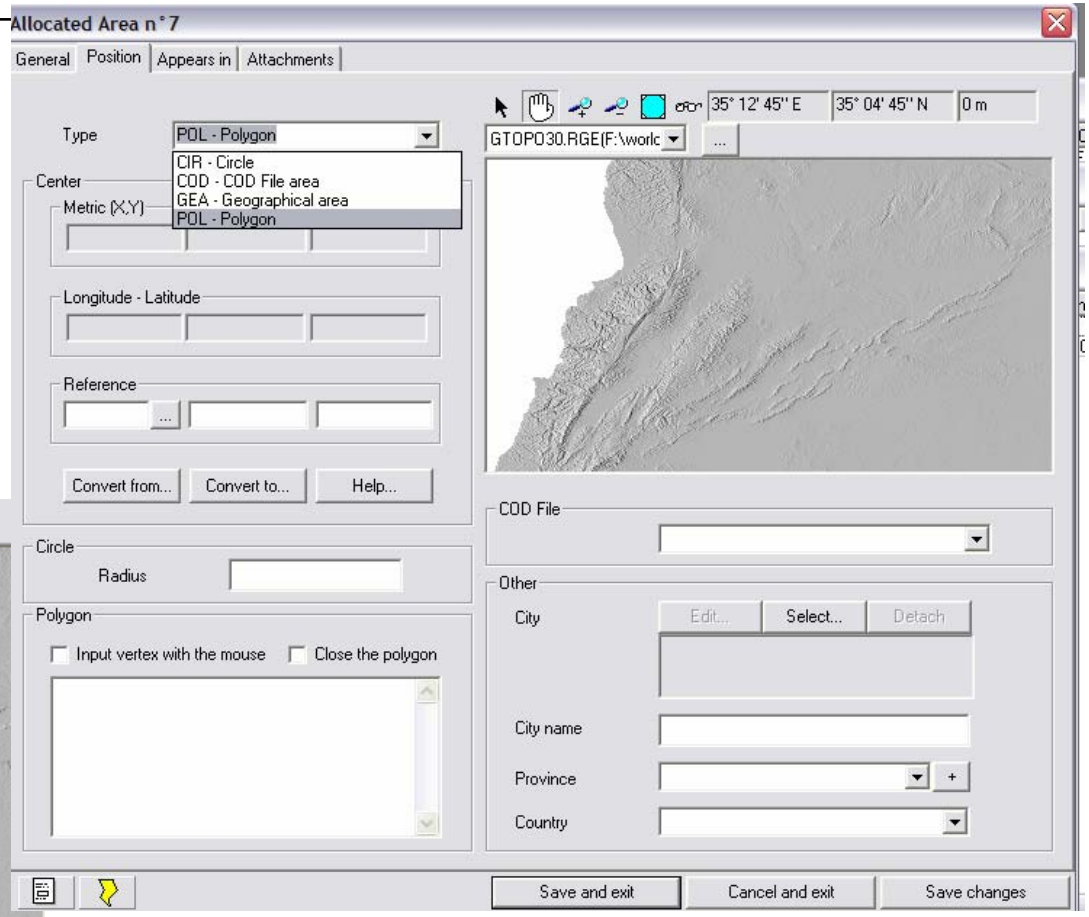


# Determining an Allotment

Select the type of frame:

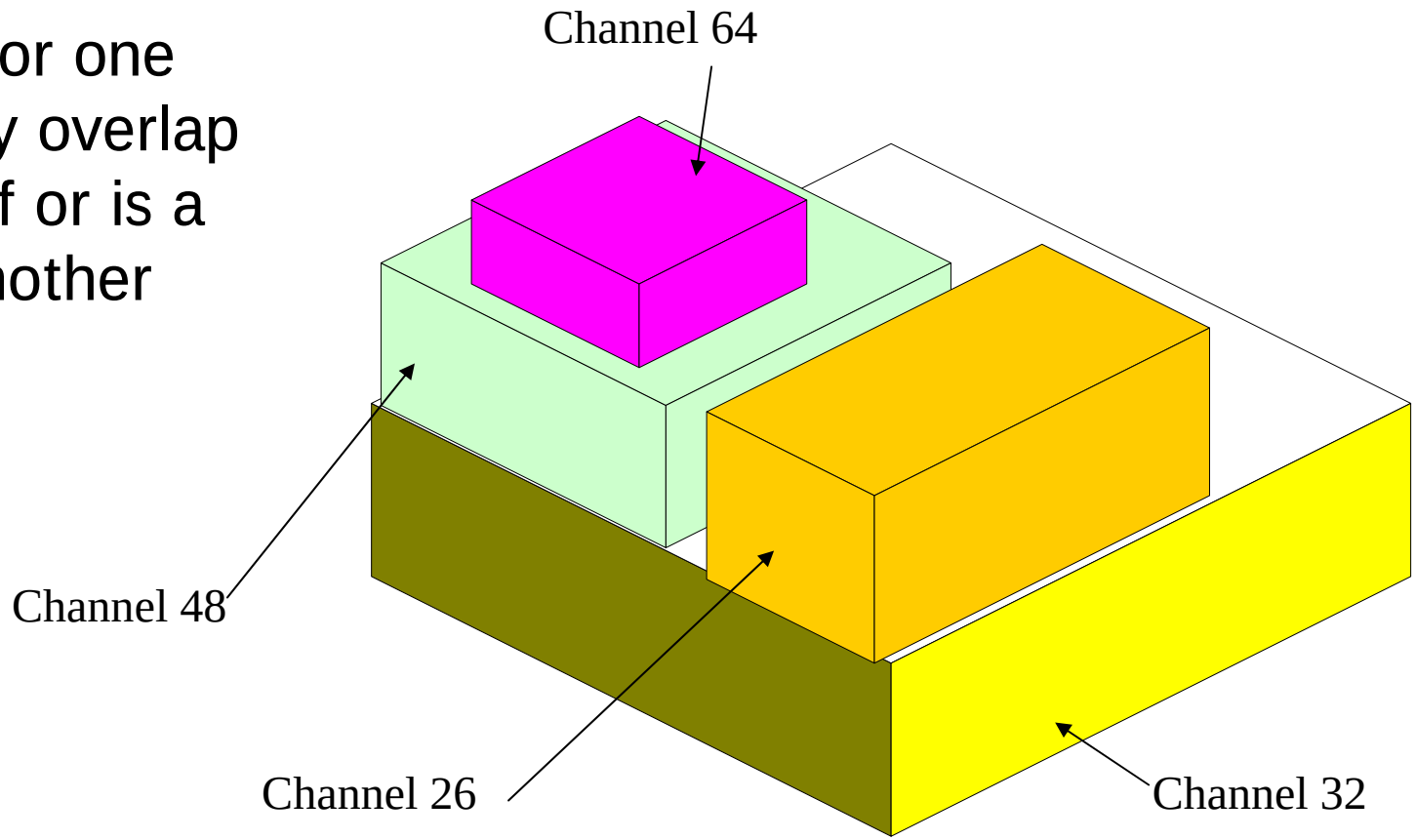
- Circle
- coded polygon file
- geographical area
- polygon
- or area around a city



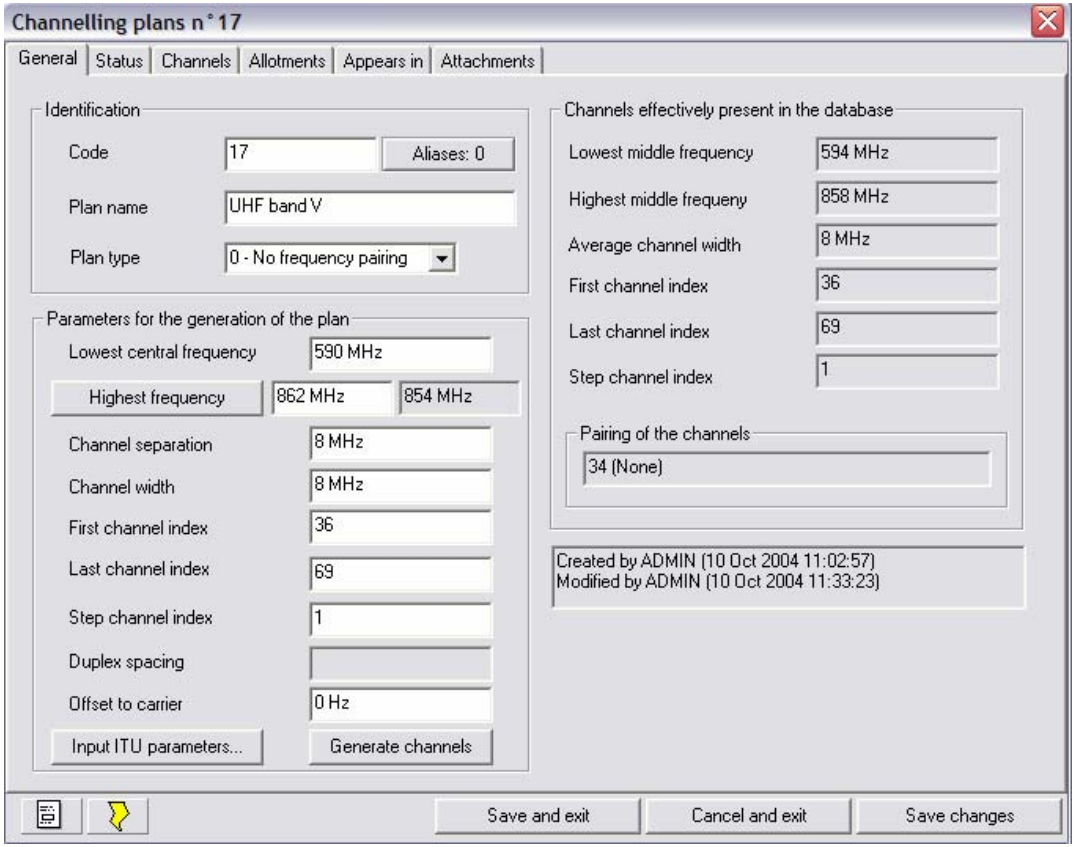



# Allotments inlets

Allotments for one channel may overlap or be part of or is a subset of another allotment

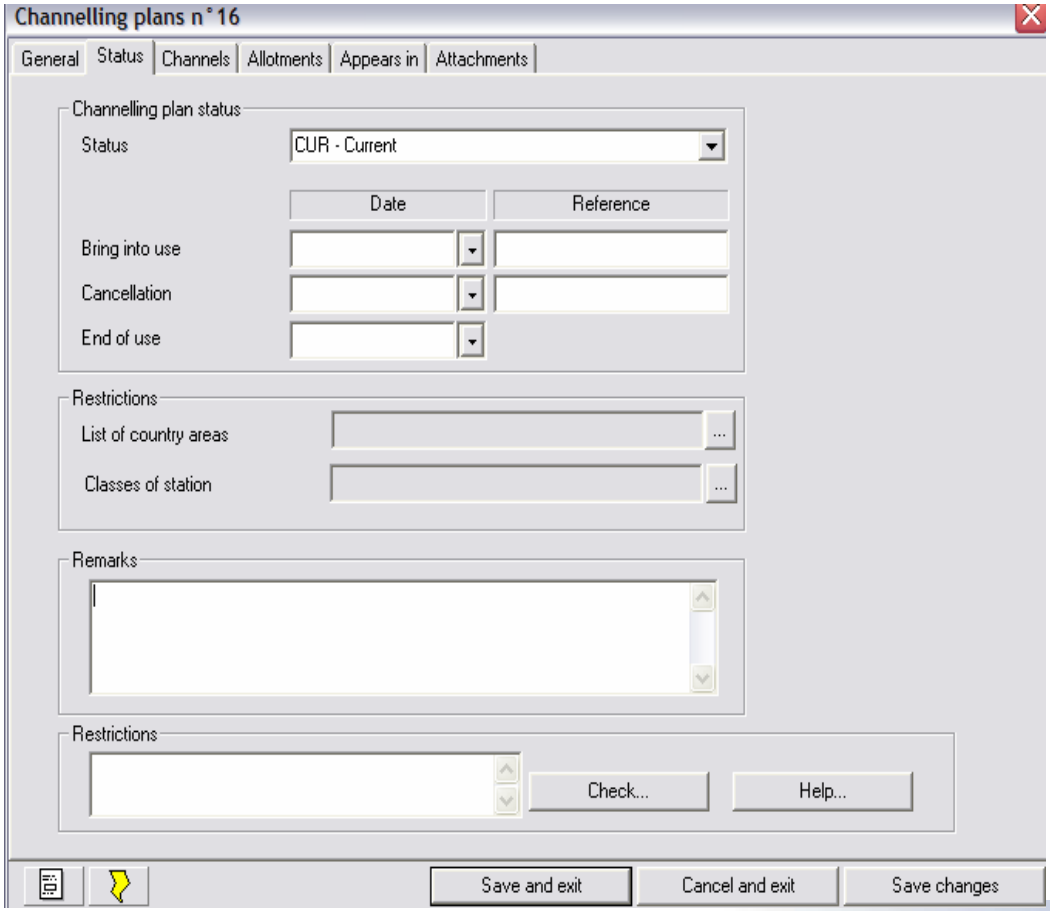


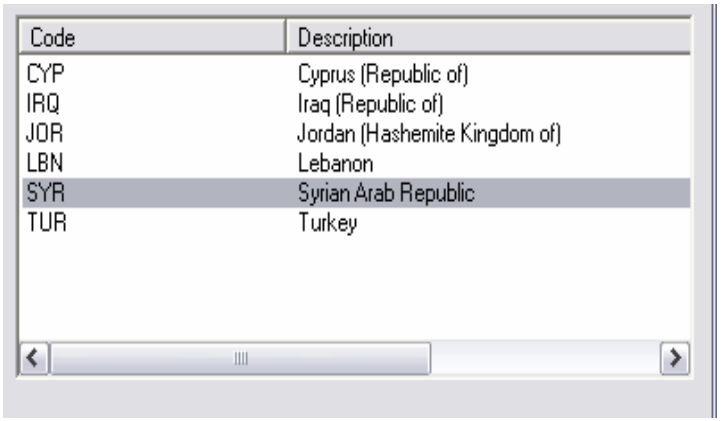
# Creating a channeling plan




Channeling plans specify the technical characteristic of a channel to be assigned

# Administrating a channeling plan

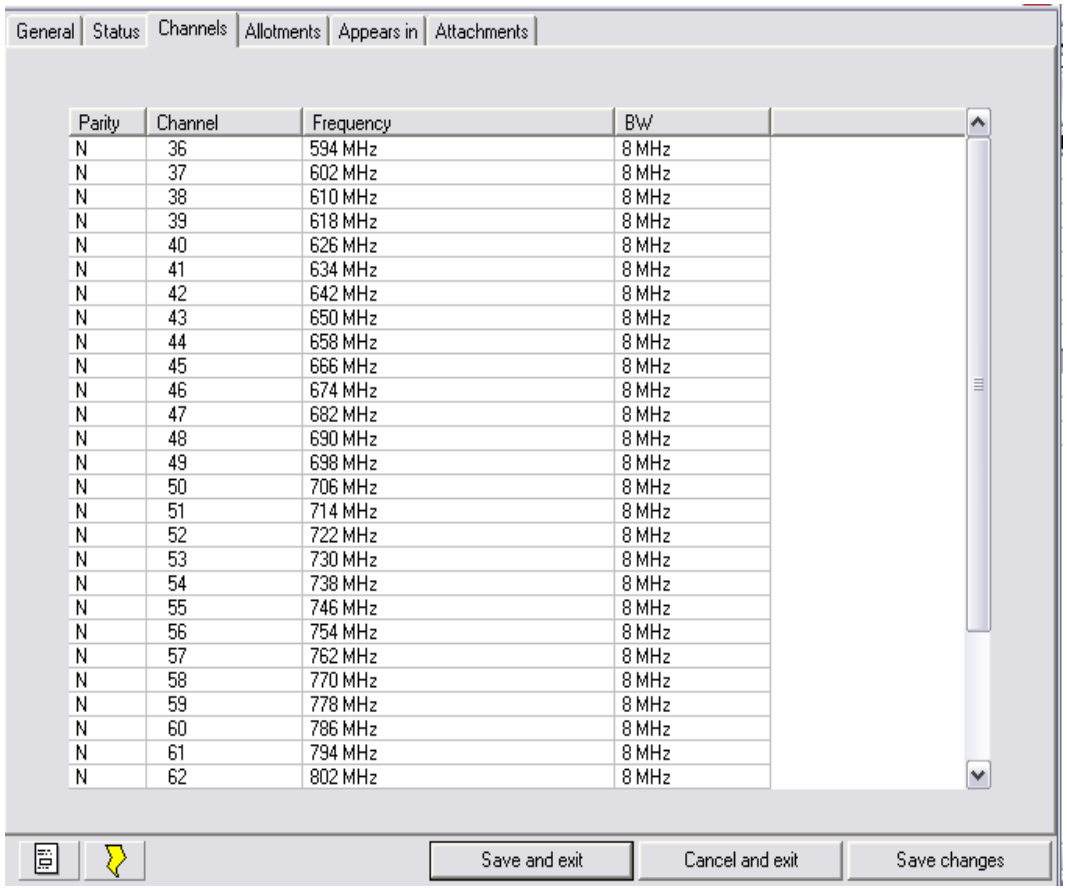


| Code | Description |
|---|---|
| CYP | Cyprus (Republic of) |
| IRQ | Iraq (Republic of) |
| JOR | Jordan (Hashemite Kingdom of) |
| LBN | Lebanon |
| SYR | Syrian Arab Republic |
| TUR | Turkey |

Specify the Status
Specify the geographical restriction
Specify the class of station
Verify the channels created versus any restriction

# Viewing the available channels




All available channels created for an assignment can be displayed

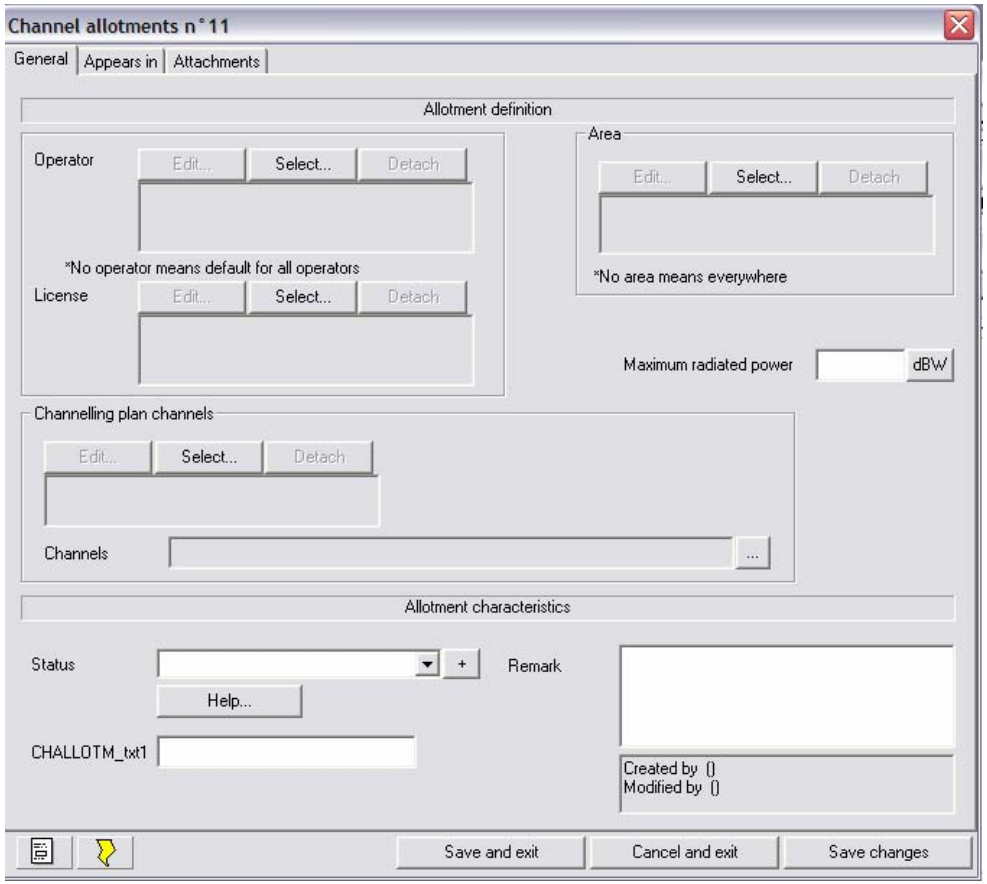
# Frequency allocation

# Existing Assignment

| ID | * ... | C... | * Frequency | Call sign | Position | Program | Longitude | Latitude | Distance(km) |
|---|---|---|---|---|---|---|---|---|---|
| 4714 | JOR | | 474 MHz | | BIR KIDAD | | 35° 33' 00" E | 30° 27' 00" N | |
| 4637 | JOR | | 474 MHz | | TEL ASFAR | | 36° 54' 00" E | 32° 11' 00" N | |
| 4520 | SYR | | 474 MHz | | BLOUDAN | | 36° 10' 00" E | 33° 46' 00" N | |
| 4503 | SYR | | 474 MHz | | ALTHAWRA | | 38° 32' 00" E | 35° 50' 00" N | |
| 4502 | SYR | | 474 MHz | | SALENFEH | | 36° 13' 00" E | 35° 36' 00" N | |
| 4383 | SYR | | 474 MHz | | HAMA | | 36° 48' 00" E | 35° 08' 00" N | |
| 4713 | JOR | | 474 MHz | | BEIT RAS | | 35° 51' 00" E | 32° 36' 00" N | |
| 4494 | SYR | | 474 MHz | | PALMYRA | | 38° 15' 00" E | 34° 33' 00" N | |
| 4776 | JOR | | 474 MHz | | BIR-KHIDAD | | 35° 32' 00" E | | |
| 4773 | JOR | | 474 MHz | | BEIT-RAS | | 35° 51' 00" E | | |
| 4305 | SYR | | 474 MHz | | HAMA | | 36° 48' 00" E | | |
| 4770 | JOR | | 474 MHz | | TEL-ASFER | | 36° 53' 00" E | | |
| 4398 | SYR | | 474 MHz | | TARTUS | | 35° 54' 00" E | | |
| 4785 | JOR | | 482 MHz | | KARAK | | 35° 42' 00" E | | |
| 4516 | SYR | | 482 MHz | | AL HOSSEN | | 36° 44' 00" E | | |
| 4699 | JOR | | 482 MHz | | EIMA | | 35° 36' 00" E | | |
| 4306 | SYR | | 482 MHz | | DAMASCUS | | 36° 10' 00" E | | |
| 4639 | JOR | | 482 MHz | | KARAK | | 35° 42' 00" E | | |
| 4715 | JOR | | 482 MHz | | WADI MOUSSA 2 | | [illegible] | | |
| 4384 | SYR | | 482 MHz | | DAMASCUS | | [illegible] | | |
| 4638 | JOR | | 482 MHz | | JABAL TAJ | | [illegible] | | |
| 4782 | JOR | | 482 MHz | | JABAL-TAJ | | 35° 42' 00" E | | |
| 4492 | SYR | | 482 MHz | | LATAKIA | | 35° 50' 00" E | | |
| 4779 | JOR | | 482 MHz | | WADI-MOUSA | | 35° 28' 00" E | | |
| 4767 | JOR | | 482 MHz | | EIMA | | 35° 36' 00" E | | |
| 4399 | SYR | | 490 MHz | | AFRIEN | | 36° 41' 00" E | | |
| 4414 | SYR | | 490 MHz | | NABISALEH | | 36° 15' 42" E | | |
| 4506 | SYR | | 490 MHz | | ALTHAWRA | | 38° 32' 00" E | 35° 50' 00" N | |
| 4487 | SYR | | 490 MHz | | KALDOUN | | 36° 42' 00" E | 33° 52' 00" N | |
| 4504 | SYR | | 490 MHz | | TAL SHAAF | | 36° 30' 00" E | 32° 34' 00" N | |
| 4307 | SYR | | 498 MHz | | HAMA | | 36° 48' 00" E | 35° 08' 00" N | |
| 4640 | JOR | | 498 MHz | | TEL ASFAR | | 36° 54' 00" E | 32° 11' 00" N | |
| 4991 | CYP | | 498 MHz | | MOUNT OLYMPUS | | 32° 52' 00" E | 34° 56' 00" N | |
| 4500 | SYR | | 498 MHz | | SAROUKHIEH | | 36° 00' 00" E | 33° 38' 00" N | |
| 4385 | SYR | | 498 MHz | | HAMA | | 36° 48' 00" E | 35° 08' 00" N | |
| 4771 | JOR | | 498 MHz | | TEL-ASFER | | 36° 53' 00" E | 32° 11' 00" N | |
| 4495 | SYR | | 498 MHz | | PALMYRA | | 38° 15' 00" E | 34° 33' 00" N | |
| 4430 | SYR | | 498 MHz | | BASHTAR | | 35° 55' 32" E | 34° 58' 59" N | |
| 4405 | SYR | | 498 MHz | | ALSUEIDA | | 36° 42' 30" E | 32° 42' 00" N | |
| 4431 | SYR | | 498 MHz | | LATAKIA | | 35° 50' 00" E | 35° 34' 00" N | |
| 4421 | SYR | | 506 MHz | | SALENFEH | | 36° 13' 10" E | 35° 36' 07" N | |
| 4524 | SYR | | 506 MHz | | BOURDEH | | 36° 06' 00" E | 34° 57' 00" N | |
| 4642 | JOR | | 506 MHz | | KARAK | | 35° 42' 00" E | 31° 11' 00" N | |
| 4386 | SYR | | 506 MHz | | NEBEK | | 36° 45' 00" E | 34° 00' 00" N | |
| 4786 | JOR | | 506 MHz | | KARAK | | 35° 42' 00" E | 31° 10' 00" N | |
| 4510 | SYR | | 506 MHz | | ALSUEIDA | | 36° 42' 00" E | 32° 42' 00" N | |
| 4308 | SYR | | 506 MHz | | NEBEK | | 36° 45' 00" E | 34° 00' 00" N | |

| | | | | |
|---|---|---|---|---|
| JOR | | 482 MHz | | WADI MOUSSA 2 |
| SYR | | 482 MHz | | DAMASCUS |
| JOR | | 482 MHz | | JABAL TAJ |
| JOR | | 482 MHz | | JABAL-TAJ |
| SYR | | 482 MHz | | LATAKIA |
| JOR | | 482 MHz | | WADI-MOUSA |
| JOR | | 482 MHz | | EIMA |
| SYR | | 490 MHz | | AFRIEN |
| SYR | | 490 MHz | | NABISALEH |
| SYR | | 490 MHz | | ALTHAWRA |

# Providing an allotment




- Select the operator
- Select the area
- Select the license
- Select the area
- Select the channels
- Specify the maximum radiated power
- Specify any allotment characteristics