

**WRAP<sup>®</sup>**

**ALL YOU NEED FOR SPECTRUM MANAGEMENT**

**COMPUTERISED  
SPECTRUM MANAGEMENT**

## CONTENTS

<b>BASIC REQUIREMENTS .....</b>	<b>3</b>
<b>EXAMPLE OF AN INTEGRATED SPECTRUM MANAGEMENT SYSTEM.....</b>	<b>5</b>
<b>WORK PROCEDURE.....</b>	<b>7</b>
APPLICATION DATA.....	7
PERFORM “SANITY CHECK”, CALCULATE LINK PERFORMANCE .....	8
SEARCH THE NATIONAL STATION DATABASE (AND OTHER DATABASES).....	9
PERFORM FREQUENCY ASSIGNMENT.....	9
PERFORM INTERFERENCE CHECK .....	10
<i>Perform Collocation Interference check.....</i>	<i>11</i>
<i>Perform checks for potential international interference.....</i>	<i>11</i>
COORDINATE WITH NEIGHBOURS.....	12
ISSUE LICENCE .....	12
PERFORM NOTIFICATION TO THE ITU .....	13
<b>CONCLUSIONS.....</b>	<b>13</b>
<b>INTRODUCTION TO USING WRAP.....</b>	<b>14</b>
STARTING WRAP .....	14
HELP FUNCTION AND DOCUMENTATION .....	15
OPENING A PROJECT.....	16
<b>EXERCISE 1: PLANNING A MICROWAVE LINK NETWORK.....</b>	<b>17</b>
INPUT DATA.....	17
ENTRY OF STATIONS .....	18
CALCULATE LINK PERFORMANCE .....	23
INTERFERENCE ANALYSIS.....	24
<i>Interference within the network .....</i>	<i>24</i>
<i>Interference from other stations.....</i>	<i>25</i>
CHECKING FOR COLLOCATION INTERFERENCE.....	26
FREQUENCY ASSIGNMENT .....	27
<b>EXERCISE 2: EARTH STATION COORDINATION .....</b>	<b>28</b>
<b>EXERCISE 3: LICENSING .....</b>	<b>30</b>
<b>EXERCISE 4: COORDINATION AND NOTIFICATION.....</b>	<b>32</b>

# Computerised Spectrum Management

Olov Carlsson  
Head, Spectrum Management  
AerotechTelub  
SE-351 80 Vaxjo  
Sweden  
olov.carlsson@aerotechtelub.se  
Tel +46-470-42149  
Fax +46-470-42042

*Spectrum Management is a very complex process, involving many steps and considerations that need to be observed to allow interference-free services and an efficient utilisation of the radio spectrum. This process can no longer be handled by manual means with the large number of users of the spectrum and the high economical and political value of radio frequencies. Efficient computer support is needed. Some functions that should be part of computerised spectrum management systems are described in this presentation, with AerotechTelub's commercial system WRAP serving as the example. The text is aimed at systems for spectrum management at a national level, which are typically characterised by multi-service capabilities including support for international coordination.*

---

## BASIC REQUIREMENTS

---

To fully support the spectrum management process there is a need for an integrated system, where multiple users can access information, perform technical analyses, perform administrative processes, share work, pass on work tasks and store results and documents. The basic requirement arising out of this is that there is a common database of information on radio stations that can be accessed by all users. The normal configuration would be to have a central database on a server, which can also conveniently be used for storing results from calculations, documents etc. that form part of the spectrum management process. Access rights for changing data in the database should be controlled, while there should be read-only access for all users. Data integrity should be maintained by scheduled automatic back-ups and preferably non-interruptible power supply.

The ability to handle various station databases is extremely important. These can be available from the ITU, such as the International Frequency List (now superseded by the ITU BR IFIC - International Frequency Information Circular). National station data held by the licensing authority should ideally comprise all radio emitters in a country, however military frequency utilisation is often based on specific allocations, where the civil authorities do not have information on the detailed frequency assignments and allotments. In any case there is an advantage if the spectrum management system can handle

all these three sources of spectrum data: International, national civil and national military data.

The various station databases may be for read-only or read/write, depending on their application and the role of a particular user. The BR IFIC is obviously read-only, the civil national station database read-only if used by a military spectrum management agency and parts of the data in the national station database may be read-only for different categories of personnel or for particular applications.

Much of the work with radiocommunication systems is geographically related, where it is most convenient to have presentations of stations on a map background on screens and printouts. Accurate calculations of field strengths and signal levels require methods for propagation calculations that account for detailed terrain features, that can be stored in terrain databases. The typical set of geographical databases needed for these purposes are

- Map images, typically derived from the scanning of paper maps (or by using digital sources directly, if available)
- Elevation data
- Terrain classification (“clutter” codes)
- Sometimes there may be an interest in using aerial photographs and/or satellite images.

Geographical databases often are a cost-driving factor for a spectrum management system, and reduced functionality modes should be available, for instance by implementing propagation models that do not require detailed terrain information.

The IDWM (ITU Digitized World Map) provides coastal contours and national borders. This data is useful for presentation of large areas, to provide some geographical orientation for the user. Another important information capability of the IDWM is when implementing certain calculation models to utilise the land/sea information and rain climate zones available in the IDWM. The propagation model ITU-R P.370 and the ITU Radio Regulations Appendix S7 (Earth station coordination contours) can make use of the IDWM.

An integrated spectrum management system should support the following types of work:

- Technical analyses of radiocommunication systems, including performance within the systems and the interference between systems
- Licensing
- Coordination and notification
- Various administrative tasks (searches, listings, statistics etc. of contents in database).

---

## EXAMPLE OF AN INTEGRATED SPECTRUM MANAGEMENT SYSTEM

---

WRAP - AerotechTelub's system for spectrum management - is fully integrated as described before. Within a single main screen interface it provides the following functions.

The Map Viewer constitutes the main *Presentation Tool* and performs all presentations using geographical data, either as a profile viewer, a common 2-D map or as a full 3-D map. The Map Viewer works with any combination of geographical data, results and scanned map images.

The *Calculation Tools* are capable of performing a large number of different tasks, supporting different radio services:

**1. Coverage**

To calculate signal levels, field strengths, radio-optical visibility, signal-to-interference ratio, required antenna height, clearance, terrain clearance angle, best server and number of servers for single or multiple transmitters/receivers. This is used for the analysis of area coverage.

**2. Interference**

To calculate interference between stations located some distance apart.

**3. Radio Link Performance**

To calculate the performance of radio links, fading margins and unavailable time.

**4. Spectrum Viewer**

To provide a visual overview of the spectrum occupancy at a selected geographical point, based on the contents of the station databases.

**5. Collocation Interference**

To calculate the interference situation in confined locations where many stations may interfere within a small area.

**6. Frequency Assignment**

To perform automatic and manual frequency assignment.

**7. Radar Coverage**

To calculate the coverage for radar stations, based on radio-optical visibility or the two-way radar propagation path.

**8. Coverage Comparison**

To perform comparisons and statistical analysis between measured coverage data and predicted coverage. To perform comparisons between coverage data that have been predicted with different propagation models or with different parameters.

**9. Earth Station Coordination**

To calculate the coordination contours around earth stations operating in bands shared with terrestrial services.

**10. Traffic Capacity**

To calculate and design the traffic capacity of cellular networks.

**11. Broadcast**

For interference analysis and frequency assignment for sound and television broadcast networks, implementing the specific recommendations, protection ratios etc. in common use for these services.

**12. Interference between satellite networks**

To calculate the interference between satellite networks. Can also be used to calculate the interference between terrestrial stations and satellites.

Many of the calculations involve the prediction of radio wave propagation, and there are several selectable models available to fit the desired applications.

**Models based on detailed terrain information:**

- ITU-R P.526: Propagation by diffraction
- ITU-R P.452: Prediction procedure for the evaluation of microwave interference between stations on the surface of the earth at frequencies above about 0.7 GHz.
- DETVAG 90/FOA (The Swedish Defence Research Agency), implementing several different diffraction methods, spherical earth methods and weighting/selection methods between these.

**Models based on coarse terrain and land cover information:**

- DETVAG 90/FOA for low-frequency calculations of ground wave propagation, based on the GRWAVE model with Millington and other extensions
- ITU-R P.370: VHF and UHF propagation curves for the frequency range from 30 MHz to 1000 MHz (uses the ITU Digitized World Map for land/sea determination)

**Statistical models:**

- Longley-Rice: Prediction of Tropospheric Radio Transmission Loss Over Irregular Terrain
- COST-231 – Hata
- COST-231 – Walfish-Ikegami

In addition to all these models the attenuation due to atmospheric gases can be added in accordance with the ITU Rec. P.676 *Attenuation of atmospheric gases*. Rain attenuation and hydro-meteor scatter are also handled. For earth-to-space paths the ITU Radio Regulations Appendix S8 "Method of calculation for determining if coordination is required between geostationary-satellite networks sharing the same frequency bands" is implemented, extended with the ability to select a more accurate propagation model as defined in ITU-R Recommendation P.619-1, items "Basic transmission loss",

“Tropospheric scintillation” (from ITU-R Rec. P.618-6), “Ray bending” and “Precipitation scatter” (from ITU-R Rec. P.452-9).

The *Administrative Tools* consist of two different parts, both operating on the same station database as the technical system:

1. Integrated Administrative Functions. These functions form an integrated part of the WRAP system and provide access for reading and writing of data in the station database.
2. Extended Administrative Functions.
  - *Licence Manager*, to handle licensing. The generation and handling of notification forms such as the ITU BR T-series forms are included in this function.
  - Other specific administrative function can be developed, operating on the open common station database.

---

## WORK PROCEDURE

---

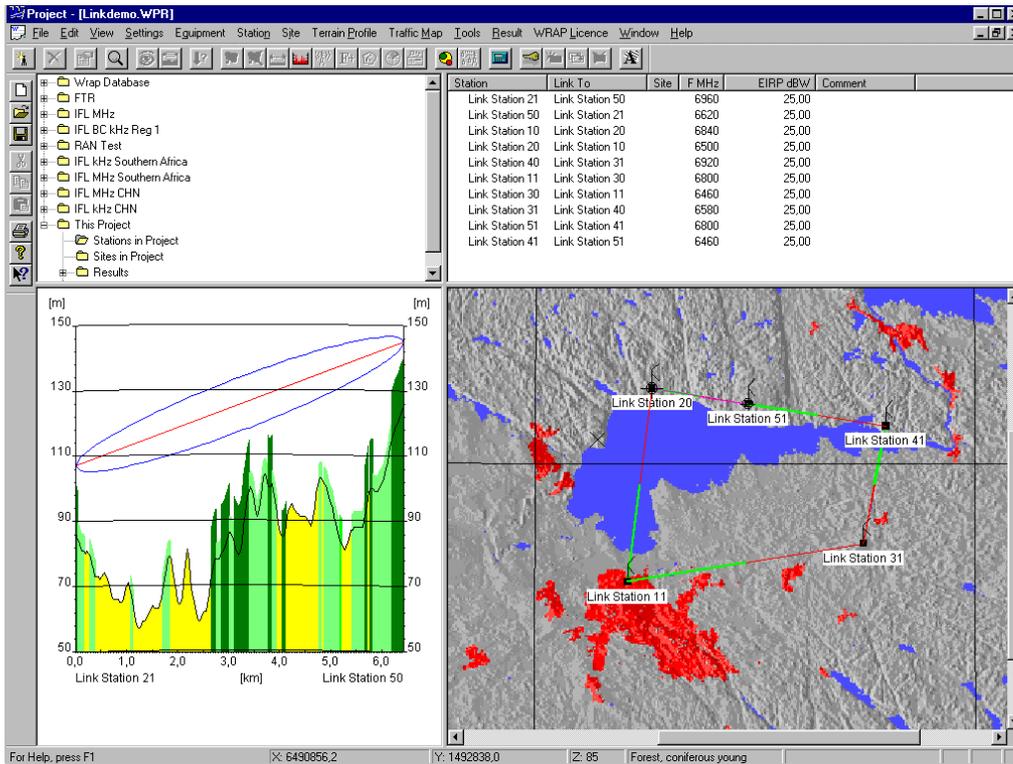
An example will be used to illustrate the benefits with an integrated system, based on a licence application for a microwave radio link network. This is based on an anticipated work-flow starting with a licence application and ending with issuing the licence, and if required, the notification to the ITU BR of the new stations.

### APPLICATION DATA

The applicant should have listed basic facts about the stations for which a licence is sought. This typically includes geographical locations, antenna height above ground, transmitter power, antenna gains, required received signal level, required signal-to-interference ratio etc. The applicant may already have a preferred frequency band of operation and even suggestions of frequency assignment. Each licensing authority may have different requirements for the submission of data in the application, some requiring also a specification of which equipment that will be used to check for compliance with type approval standards. For this example it is sufficient with the parameters that constitute important data for the analysis of link performance and interference.

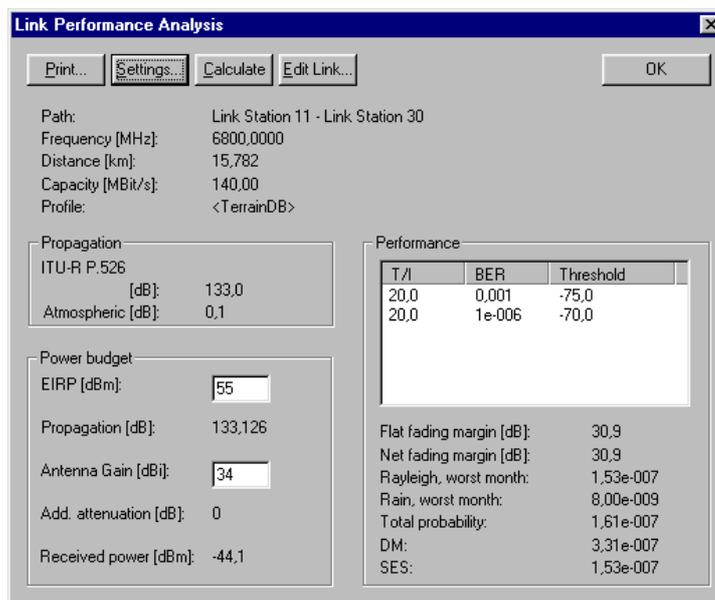
#### **Make project for calculations etc.**

Data for the stations are entered into the spectrum management system in a temporary workspace. The purpose for this is to have all relevant data under control to support the subsequent stages in the process. But this is still an on-going process, so the data should not yet be stored in the national station database.



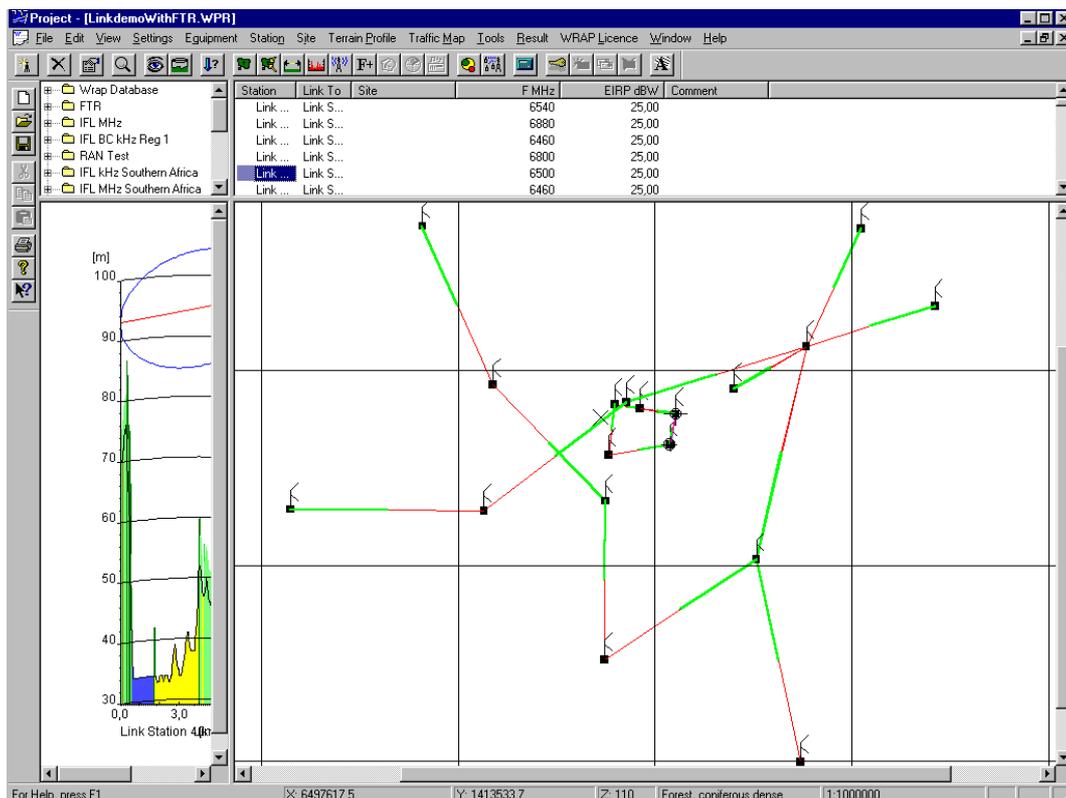
**PERFORM “SANITY CHECK”, CALCULATE LINK PERFORMANCE**

The applicant should have performed basic link budget calculations and designed the links for the appropriate quality and availability. The licensing authority should nevertheless check the link performance for suitable design, for instance to make sure that the radiated power is reasonable so as not to create larger interference regions than necessary.



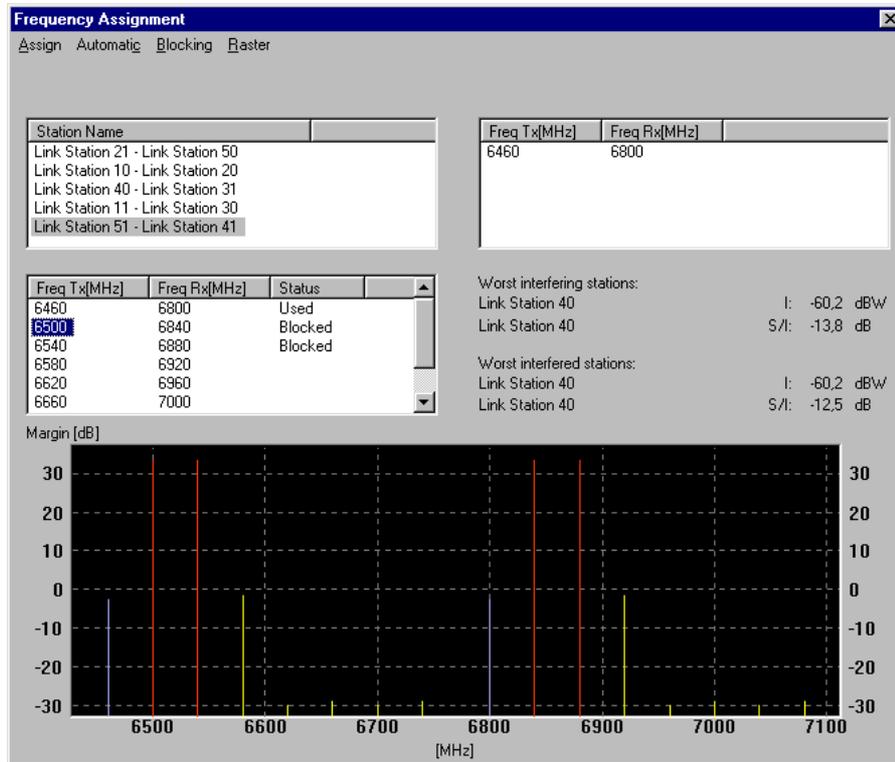
## SEARCH THE NATIONAL STATION DATABASE (AND OTHER DATABASES)

To provide basis for the continued process for frequency assignment and interference analysis there is a need to examine the frequency utilisation in the geographical area and frequency band of interest. This is done by searching the available station databases with geographically limited and frequency-limited criteria. Stations that are found, which are suspected to be subjected to interference from the new stations, or that may interfere with the new stations should be entered into the calculation project for further analysis. This is done automatically (if selected) in WRAP.



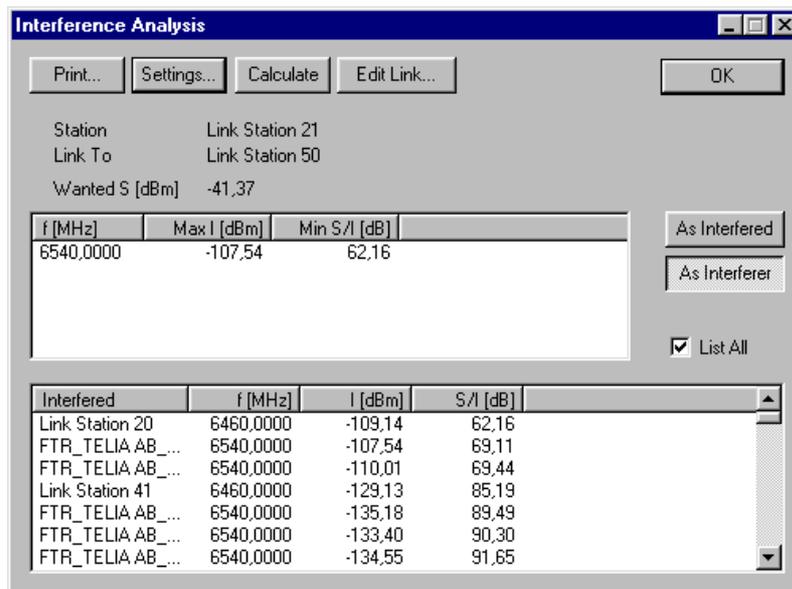
## PERFORM FREQUENCY ASSIGNMENT

The frequency assignment function is used to assign frequencies to the new stations. Account is taken automatically to the interference from the new stations to the existing stations and the interference from the existing stations to the new stations. The frequency raster should naturally be compliant with the frequency plan for the band of operation. An appropriate propagation model should be selected to provide protection for the desired percentage of time.



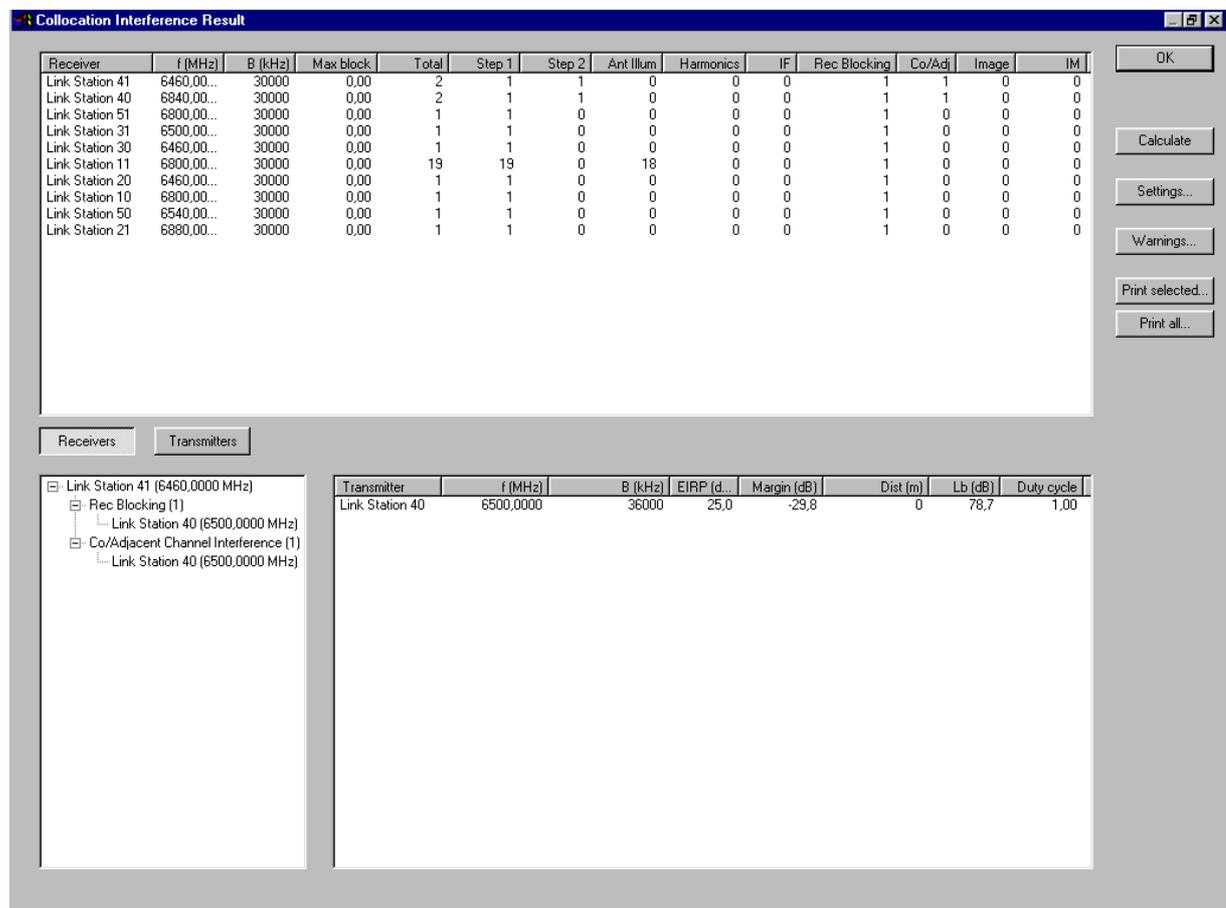
**PERFORM INTERFERENCE CHECK**

The automatic assignment process accounts properly for the interference contributions from new and existing stations, but there may be an interest to analyse and quantify the resulting interference margins by a specific interference check. In this process it is easy to find the most contributing interferer and to judge whether its contribution is acceptable.



### Perform Collocation Interference check

The specific locations for the new stations would normally have been selected by the applicant to be suitable from a linking point of view. The applicant may or may not have the capabilities to judge whether the local interference situation at the intended site for installation may pose a problem. The licensing authority probably has a better knowledge about at least the already licensed stations at the sites, and should have the capability to examine the frequency assignment for local interference such as inter-modulation, harmonics, transmitter spectrum mask and receiver selectivity. For really detailed and accurate collocation interference analysis there is a need for quite detailed performance data of receivers and transmitters, as well as very detailed information on the exact locations of antennas at the site. This level of detail normally goes beyond the responsibility of the licensing authority, but it may anyway perform some calculations and provide guidance to the applicant or express concern that more detailed investigations should be performed.



**Collocation Interference Result**

Receiver	f (MHz)	B (kHz)	Max block	Total	Step 1	Step 2	Ant Illum	Harmonics	IF	Rec Blocking	Co/Adj	Image	IM
Link Station 41	6460,00...	30000	0,00	2	1	1	0	0	0	1	1	0	0
Link Station 40	6840,00...	30000	0,00	2	1	1	0	0	0	1	1	0	0
Link Station 51	6800,00...	30000	0,00	1	1	0	0	0	0	1	0	0	0
Link Station 31	6500,00...	30000	0,00	1	1	0	0	0	0	1	0	0	0
Link Station 30	6460,00...	30000	0,00	1	1	0	0	0	0	1	0	0	0
Link Station 11	6800,00...	30000	0,00	19	19	0	18	0	0	1	0	0	0
Link Station 20	6460,00...	30000	0,00	1	1	0	0	0	0	1	0	0	0
Link Station 10	6800,00...	30000	0,00	1	1	0	0	0	0	1	0	0	0
Link Station 50	6540,00...	30000	0,00	1	1	0	0	0	0	1	0	0	0
Link Station 21	6880,00...	30000	0,00	1	1	0	0	0	0	1	0	0	0

Transmitter	f (MHz)	B (kHz)	EIRP (d...)	Margin (dB)	Dist (m)	Lb (dB)	Duty cycle
Link Station 40	6500,0000	36000	25,0	-29,8	0	78,7	1,00

Receivers: [ ] Transmitters: [x]

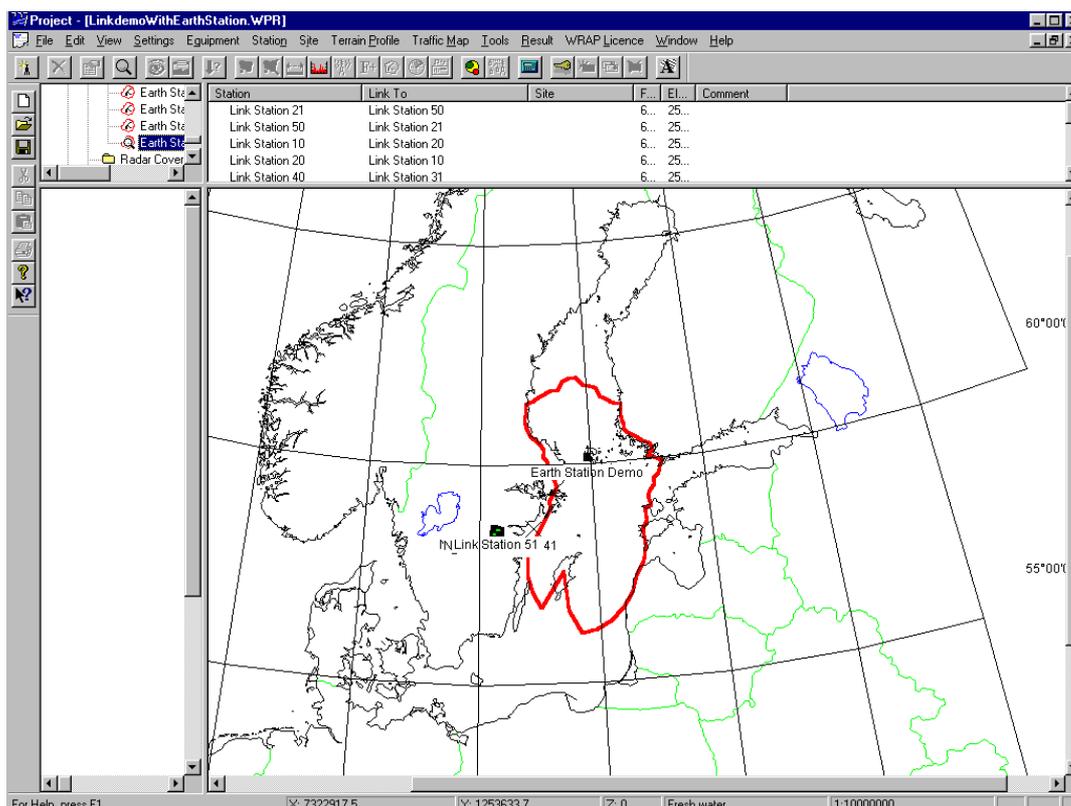
- [-] Link Station 41 (6460,0000 MHz)
  - [ ] Rec Blocking (1)
    - [ ] Link Station 40 (6500,0000 MHz)
  - [ ] Co/Adjacent Channel Interference (1)
    - [ ] Link Station 40 (6500,0000 MHz)

### Perform checks for potential international interference

The BR International Frequency Information Circular should be consulted for potential interference to or from stations in countries within a typical coordination distance. Bi-lateral or multi-lateral coordination agreements may already have been established incorporating coordination zones, in which case the search can be limited to within the zone along the border. Otherwise interference calculations should be performed, with

station characteristics determined from the BR IFIC and complemented with appropriate additional data if needed.

Earth stations in frequency bands shared with the terrestrial services can be found in the BR IFIC/Space Radiocommunications Stations database. Data for these stations can be extracted and entered as characteristic earth station data for generation of the coordination contours using the Earth Station Coordination tool. Terrestrial stations falling within the coordination contour, with over-lapping frequency bands, should be examined further for interference potential by using the *Interference* tool.



### COORDINATE WITH NEIGHBOURS

The investigations of potential interference or location of the new stations within pre-determined coordination areas as agreed with neighbouring countries may necessitate coordination with authorities of neighbouring countries. This should be performed in accordance with coordination agreements (if they exist). The generation of the appropriate ITU T-series notification form can be done to support the coordination.

### ISSUE LICENCE

Pending the outcome of the coordination (if needed), a temporary licence may be issued. In many cases it will be obvious for the licensing authority whether the coordination process will have a positive outcome, so that the licence can be issued before the coordination is completed.

### PERFORM NOTIFICATION TO THE ITU

The appropriate notification form can be completed and sent to the ITU BR (if needed). In this example it would be the T11 form. The system provides tracking of the notification process and allows for the suppression and modification of the notifications.

---

## CONCLUSIONS

---

Great advantages can be gained by implementing an integrated, computerised spectrum management system through the convenient and rational handling of the complete process, including technical analysis, licensing and coordination. The foundation for such a system is a common station database, that holds all relevant data and that is accessible for all personnel working with various parts of the spectrum management process.

The system should incorporate suitable functions to allow technical analysis of the wide variety of radiocommunication systems that are the responsibility of the spectrum management authority. This calls for the implementation of a number of radio wave propagation models as well as analysis methods that have a general applicability. In some cases service-specific methods need to be utilised due to international agreements and recommendations, or for systems that have unique features that need to be accounted for in detail.

---

## INTRODUCTION TO USING WRAP

---

Welcome to WRAP!

WRAP provides all necessary computation and analysis support for frequency management and planning for a number of different radio services. Calculations are carried out with the aid of frequency and equipment databases or by manually entered station data. The results are presented geographically, facilitating planning and decision making. Administrative tasks such as licensing and coordination/notification are performed in the WRAP Licence Manager.

WRAP makes it easy to perform advanced tasks in one dedicated piece of software. The user interface has been carefully designed, taking full advantage of the features provided by the Win32 environment. The result is a user interface that is very powerful, yet intuitive and easy to understand. Therefore, operating WRAP requires only a minimum of computer skills.

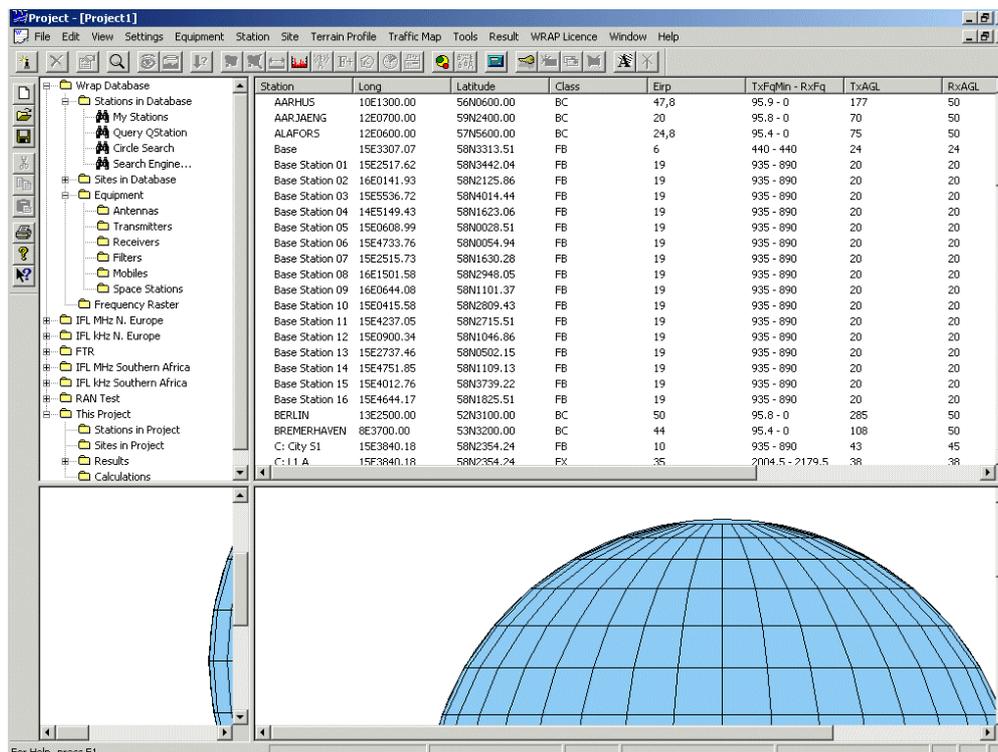
Since there are so many possibilities when working with WRAP there are some exercises to make it easier to exploit the software. These exercises will give a guidance of how to work with WRAP. The exercises are fully described in the User's Manual, Part 1.

### STARTING WRAP

The WRAP standard installation creates entries in Windows Start menu – Programs. Perform the following to start WRAP:

- Select **Start - Programs - WRAP - WRAP**. The Licence Manager is started by selecting **Start - Programs - WRAP Licence Manager - WRAPLicMan**.
- A log-in window appears (not for the Licence Manager). Select User **Guest** (no password required) or **WRAP User** (password **wrap**). **Guest** can be used for most exercises.

The following main window appears (note that the database and project folders have been expanded by clicking once on the + sign in front of some of the folders and that the search query **Query Qstation** has been executed).



The main window is divided into four major parts:

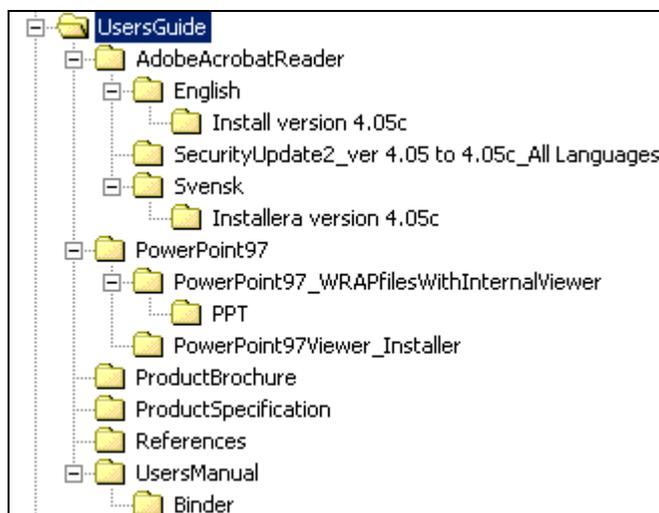
1. Upper left: Folder view with available station databases and the Project folder. The number of available databases depends on the installation.
2. Upper right: List view showing station information and equipment information (**Query Qstation** has been executed by double-clicking on the corresponding line in the upper left folder view).
3. Lower right: Geographical viewer that can be set to display a terrain profile, a two-dimensional map or a three-dimensional map.
4. Lower left: Geographical viewer that can be set to display a terrain profile, a two-dimensional map or a three-dimensional map.

At the top there is a text-based menu bar and just below you can see a icons for various tools and functions. Only those icons that are applicable to the particular view and selection of stations are highlighted and therefore available. The others are dimmed.

### HELP FUNCTION AND DOCUMENTATION

WRAP includes a Help Function, including a description of every window in the system. This is activated by pressing **F1**. The Help function opens automatically at the part that describes the window that was active when pressing **F1**.

The complete documentation for WRAP is normally available (if copied to the hard-disk) in the folder ...\**WRAP\UsersGuide** according to the following folder view:



Documents are provided in Adobe Acrobat 4.0 format. The Acrobat reader is available in the folder for installation if this program is not already installed on the computer.

The ...\**UsersManual\Binder** folder contains the complete User's Manual.

The ...\**PowerPoint97\...** folder contains Microsoft PowerPoint presentations of WRAP, both an overview and specific presentations of each major tool. They can be shown without a PowerPoint installation on the computer.

### OPENING A PROJECT

A good way of quickly getting started with WRAP is to open some of the project files that are available in the ...\**WRAP\Samples** folder. A project file includes information on stations, equipment and map settings that were used when saving the project file. Many results that were calculated can also be saved in the project file.

Perform the following to open a saved WRAP project:

- At the upper left corner: Select **File - Open...**. Go to the ...\**WRAP\Samples** folder, select the **Link Performance.WPR** file. The main window will now display a map view in the lower right geographical viewer.
- Click on the + sign in front of **This Project** folder in the upper left area of the main window. Click on the **Stations in Project** line. Now a list of stations will appear in the list view, upper right area.
- Position the cursor in the lower left area. Right-click and select **Profile**. This sets the left geographical

viewer to display the terrain profile and other information on a selected link.

- Mark the station name **Link Station 21** in the upper right list view. Notice that several of the tool icons now become active, indicated by highlighting instead of being dimmed.
- Select the icon . A window **Select a profile or terrain database** appears, since this particular link has two terrain profiles that were generated previously and stored in the station database. Select the **<TerrainDB>** option. This will display the terrain profile in the lower left area, including colour information on terrain classifications, 1<sup>st</sup> Fresnel zone and ray path, station names etc.
- Right-click in the profile view. Select **Properties...** to bring up a window where several options for the display may be selected.
- Mark all stations in the list view and select **Show In Map**. Four nodes, each containing two link stations, will appear on the map. The nodes are connected with lines, where the green colour indicates which end of the link that is transmitting on the high duplex frequency and the red colour indicates which end that is transmitting on the low frequency.

---

## EXERCISE 1: PLANNING A MICROWAVE LINK NETWORK

---

### INPUT DATA

The objective in this exercise is to plan and design a small 16 Mbit/s microwave link network in the 4 GHz band. Standard stations and equipment data available in the demo version of WRAP's station database should be used. Assume the following:

- Maximum height above ground for antenna towers is 60 metres
- Maximum single-hop distance is 40 km

- The network shall link the following towns in the county of Östergötland in Sweden:
  - Motala
  - Mjölby
  - Linköping
  - Norrköping
  - Finspång
  - and back to Motala.
- Towers can be placed at the highest points within or near the urban areas of the towns
- The fixed service band 3810.0 – 4182.5 MHz, channel separation 14.5 MHz, duplex distance 213.0 MHz shall be used.
- The non-availability requirement is an SESR (Severely Errored Seconds Ratio) in accordance with ITU-R Recommendation F.697-2, which is less than  $1.5 \times 10^{-4}$ .

### ENTRY OF STATIONS

The **Samples** folder contains a project file that sets the map view to suit this exercise. Perform the following after starting WRAP as described on page 14:

- Open the project **OstergotlandMap.WPR**. Save it again (change the name), using **Save as...** to allow saving under a new name. Saving now and then is wise if errors are made and a saved, correct version of the project needs to be retrieved.
- Right-click in the map, select **Scale - 1:500 000** (or user-defined 1:300 000). Select **Properties...**. The first tab of the window that opens shows the available geographical vector themes. Check the theme **Text, town 10000-99999**. Accept and close the window by selecting **OK**.

The map now displays the names of the towns to be linked. The centre position of the map can be adjusted by right-clicking at the desired new centre position and selecting **Centre position** in the menu.

- Right-click in the left geographical viewer and select **Profile**. This will later conveniently allow the display of the terrain profiles along the path. Take the opportunity now to set the earth radius factor to 0.6 instead of the nominal 1.33. This is done by right-clicking, selecting **Properties** and entry of 0.6.

*Note: An earth radius factor of 0.6 is commonly used when planning radio links for high time availability.*

- Right-click in the map and select **Snap to highest**. This will cause the selected station positions to automatically be placed at the highest point within a certain area around the cursor (scale-dependent size of the area).
- Position the cursor within the urban (red) area of Motala. Right-click without moving the cursor and select **Tx Position**. Notice that a cross and circle appears near the cursor position.
- Then position the cursor within the urban area of Mjölby. Right-click and select **Rx Position**. Notice that the Profile Viewer now displays the terrain profile between the two selected points.

The end points of the link have now been set. The next step is to create stations at these points. This is performed as follows:

- Select **Station - New...** in the top text menu bar. A window with a number of selectable folders appears. Choose **Fixed service, digital links**. Select **Wrap Fixed station 1-19 GHz/16 Mbit/s**.
- The **Edit Station** window opens. Give a name to the first station in the link hop (Motala). To allow easy identification of the individual links you may use the following naming convention: **Motala-to-Mjolby**.
- Select the **Frequencies** tab. Enter **4110** in the **TX Fq (MHz)** box and **3897** in the **RX Fq (MHz)** box. The TX and RX equipment have been selected automatically as defined by the template for this type of station. Press **OK**, which closes the window and automatically opens the **Edit Station** window again, this time for entry of data for the opposite station in Mjölby.
- Enter the station name, for example as **Mjolby-to-Motala**. The frequencies have been set automatically to match those that were assigned to the Motala station, i. e. TX and RX frequencies are reversed. Press **OK** to accept the entries.

A feature that allows automatic entry of existing station coordinates to a new station should be used for the continued definition of the link network. This is done by right-clicking on an existing station in the upper right list view and selecting **Set As Tx**. Then the cursor is placed at the appropriate location in the map for the selection of **Rx Position**. This is a convenient way of building a chain of link hops.

Continue as follows:

- Right-click on station **Mjolby-to-Motala** in the list view. Select **Set As Tx**.
- Position the cursor within the urban area of Linköping. Right-click and select **Rx Position**. You may need to try this a few times to find a suitable high spot.

*Hint: The map display can be changed in many respects. One way to allow quick identification of high spots is to right-click in the map and select **Properties – Raster Data – Type – Terrain heights, Floating colours**. This sets the map to display a grey-scale with the lighter shades being higher in elevation. Also make sure that the **Info** boxes are checked to display height and terrain codes in the status bar at the bottom of the main window. The z-value gives the height above sea level.*

- After selection of the new Tx position and Rx position: Again perform the **Station – New** commands and enter station names with the same naming convention. **Observe that frequencies should be reversed!**

It is common practice to make sure that each link point transmits in the same frequency band. Otherwise interference may become severe from a transmitter operating in the same band as a receiver. So ensure that frequencies are reversed. This can be checked by showing the links on the map. Correct frequency distribution is indicated when each node shows the same colour (green or red) in each of its two directions.

Continue in this manner until only the final link between Finspång and Motala remains. Perform the following:

- Mark **Finspang-to-Norrköping, Set As Tx**. Mark **Motala-to-Mjolby, Set As Rx**. Continue to assign frequencies as before.

Now the complete network can be shown on the map and each link can be analysed for the proper clearance above the terrain. Perform the following to do this:

- Right-click in the bottom left viewer, select **Profile**. Set the earth radius factor to 0.6 by right-clicking and selecting **Properties...**
- Mark all stations in the list view, select **Show In Map**. Check the frequency information (red/green) for consistency. Depending on the number of link stations there may be mismatch (odd number OK, even number there will be one mismatch). Mismatches may need to be taken care of later by proper frequency assignment or other means.

- Mark one station at the time. Click on the icon  to display the terrain profile. Attempt to achieve full clearance of the first Fresnel zone by editing the antenna heights. This is done simply by double-clicking in the Profile Viewer near the end points of the path. This opens the **Edit Station** window. Select the **Tx Equipment** and **Rx Equipment** tabs and edit the antenna heights (up to a maximum of 60 metres). The profile view is updated when the window is closed with **OK**.

This procedure should work fine for all links except for the one between Finspång and Motala. A much higher antenna height would be required here. Even with 60 metre high antennas at both ends you will probably not achieve full clearance.

Here a relay site is required. A convenient way of finding a suitable location is by using an area-coverage calculation called **Minimum Required Antenna Height**. This will show the areas that have coverage to both Motala and Finspång with a certain antenna height above ground at the relay site. Perform the following:

- Mark the stations **Finspang-to-Motala** and **Motala-to-Finspang** in the list view (any number of stations can be selected by standard Windows procedure: Press **Ctrl** and click on the station to select).
- First an area of interest, within which an appropriate site would be located, should be marked in the map. This is done by right-clicking in the map and selecting **Calculation/Search Area - Circle**. Place the cursor at the centre of the circular area to be drawn. Press the right mouse button and move the cursor until a circle of suitable size has been drawn. The circle will be defined as a purple colour when releasing the mouse button.
- Click in the icon  (**Coverage**). Make the following settings:
  - Calculation: Minimum Req Antenna Hieght
  - Above Sea Level: Unchecked
  - Clearance: 100%
  - Calculation Area: Circle, Defined in Map Viewer
  - Resolution: High
  - Effective Earth Radius Factor: 0.6
  - Description: A suitable name for the calculation.

Click on **OK** to start the calculation and close the window.

The calculation may take up to a few minutes if you are using a slow computer. The progress of the calculation can be seen in the upper left view. Perform the following to see this and set the subsequent map presentation:

- Double-click on the **Calculations** folder. The progress in percent can be seen. The result can be seen in the **Results - Coverage Results Area** folder when the calculation has finished. Open this and double-click on the result name that now has appeared.
- The **Edit Result** window appears. The **Information** tab contains some statistics on the result, such as maximum and minimum values (that is the minimum antenna height at the relay site to have 100% first Fresnel zone clearance to both Motala and Finspång). The **Presentation** tab defines the number of levels to present, their colours, patterns and line style. Press the + sign to display for instance three levels. Mark each level and set a suitable value. A selection of 30 m, 45 m and 60 m may be appropriate. Press **OK** to close the window.
- Now right-click on the result name and select **Show Cursor Value** and **Visible**. The map will now display the areas within which a relay site should be placed. Move the cursor within these areas and read the result value in the status line. Select a suitable point, right-click and select **Tx Position**.

Now two link hops need to be created to divide the original Motala – Finspång link. This can be performed conveniently by first using the **Duplicate** function to create a complete copy of the original link. Then the respective end points can be moved to the new site defined by the **Tx Position**. The station names should obviously be changed to reflect the new locations, and the frequencies need to be checked for the proper frequency arrangement at each location.

Perform the following:

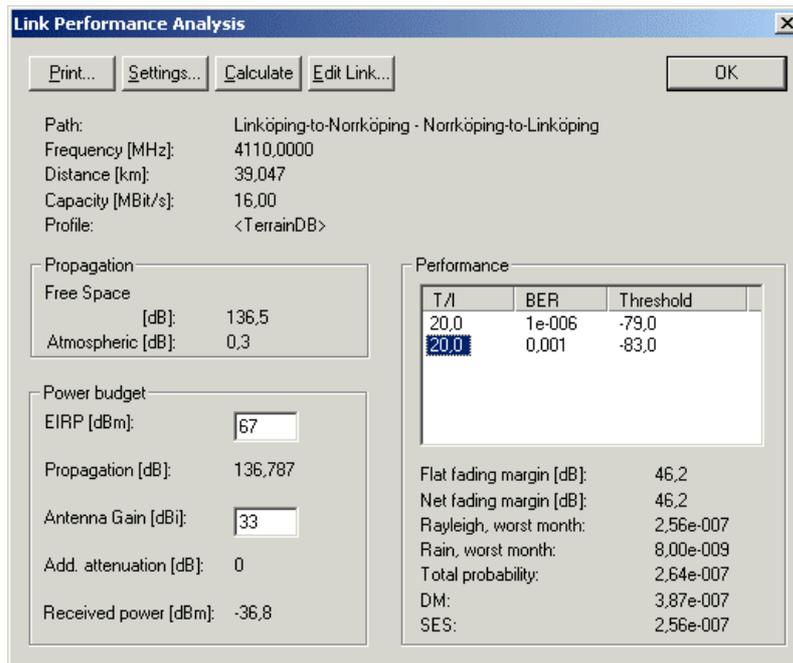
- Mark the link **Motala-to-Finspang/Finspang-to-Motala**. Right-click and select **Duplicate**. This results in a new link hop named **Copy of...** etc.
- Mark the link station **Copy of Motala-to-Finspang**. Right-click and select **Move To Tx Position**.
- Mark the link station **Copy of Finspang-to-Motala**. Right-click and select **Move to Tx Position**.

- Mark all stations in the list view and select **Show in Map**. Check the frequency indicators such that all link sites only have either red or green colours in both of their link directions. Double-click on station names that have the wrong frequency complement and edit (change Tx frequency and Rx frequency). This is done by marking the frequency, clicking on the right arrow to move the frequencies into the edit boxes and editing the frequencies there. Don't forget to click on the left arrow to move the changed frequencies back.
- Also take the opportunity to edit the station names to for instance:
  - **Relay-to-Motala**
  - **Motala-to-Relay**
  - **Relay-to-Finspang**
  - **Finspang-to-Relay**
- Mark the **Motala-to-Finspang** link, right-click and select **Delete**.
- As a final measure you should check the antenna heights for the new stations. They can probably be reduced significantly from the 60 metres maximum height.

### CALCULATE LINK PERFORMANCE

Now all links should have a reasonable free line-of-sight. The next step is to calculate the link performance. Do as follows:

- Mark a link to be analysed for link budget and availability. Select the icon  **Radio Link Performance**. The initial calculation is always performed with the Free-space propagation model, complemented with attenuation due to the atmosphere. Since all links now should have a free line-of-sight this is a valid propagation model. This opens a window as shown below.



Note that the line for **T/I 20.0 – BER 0.001 – Threshold –83.0** has been marked. This is necessary to show the result for **DM – Degraded Minutes** and **SES – Severely Errored Seconds**. The SES value constitutes the most important result, and in this case probability of unavailability due to too high bit error rate is only  $2.56 \times 10^{-7}$ , to be compared with the design objective of  $1.5 \times 10^{-4}$ . This means that the link budget can be reduced by for instance selecting antennas with lower gain or reducing the transmitter power. In this particular case it seems to be sufficient with about 40 dBm EIRP (Effective Isotropically Radiated Power). All links can be checked for availability.

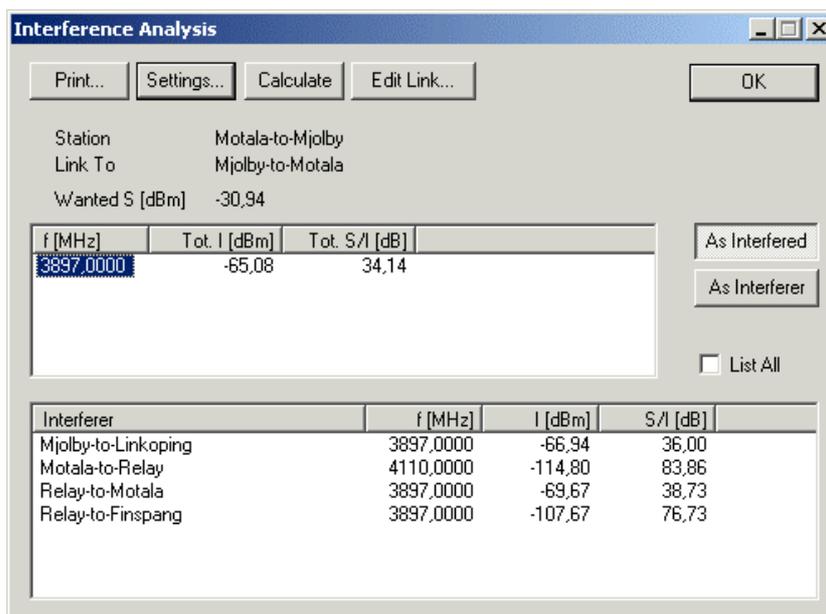
Under **Settings...** you can find selections of various methods, propagation models and atmospheric conditions and you may experiment with other settings.

## INTERFERENCE ANALYSIS

### Interference within the network

The new network should be checked for potential interference within the network and against other use of the assigned frequencies. First you may check within the network by using the **Interference** tool. Perform the following:

- Mark the first station to be checked for interference. Select the  **Interference** tool.
- Select **Settings... Propagation Model – Wanted – ITU-R P.526** and **...Interferer – ITU-R P.452**. Use the default settings for other options. Press **OK** to start the calculation and close the window. A result screen similar to the following appears:



Note that the frequency entry in the top list view has been marked to display the individual interference contributions as listed in the lower box. The total interference as received by the Motala-to-Mjolby station is  $-65$  dBm and the signal-to-interference ratio is  $34$  dB. These values are quite acceptable. Selecting the **As Interferer** function will show the interference that the transmitter of Motala-to-Mjolby causes in the other receivers in the network.

You may continue and check the remaining stations for interference.

### Interference from other stations

Interference to and from other users of the assigned frequencies should be checked. This requires knowledge of the overall frequency utilisation, such as a national master station database. WRAP supports this, but the demonstration version is limited in functionality. To demonstrate some of this it is possible to search the IFL (ITU's International Frequency List, to be replaced with the BR IFIC – International Frequency Information Circular). This requires that the IFL in WRAP format is installed, which will show up as an additional station database named IFL in the upper left database folder view.

In this particular case it is of little interest, since Sweden does not have any entries in the IFL for this frequency. Norway, Denmark and Germany have entries at both  $3897$  MHz and  $4110$  MHz, but the distance is so large that there is no potential of interference.

Anyway, the procedure is to perform a geographically limited search on the frequencies of interest. Any matching station entries in the database can then be added to the WRAP project and the interference contribution can be calculated.

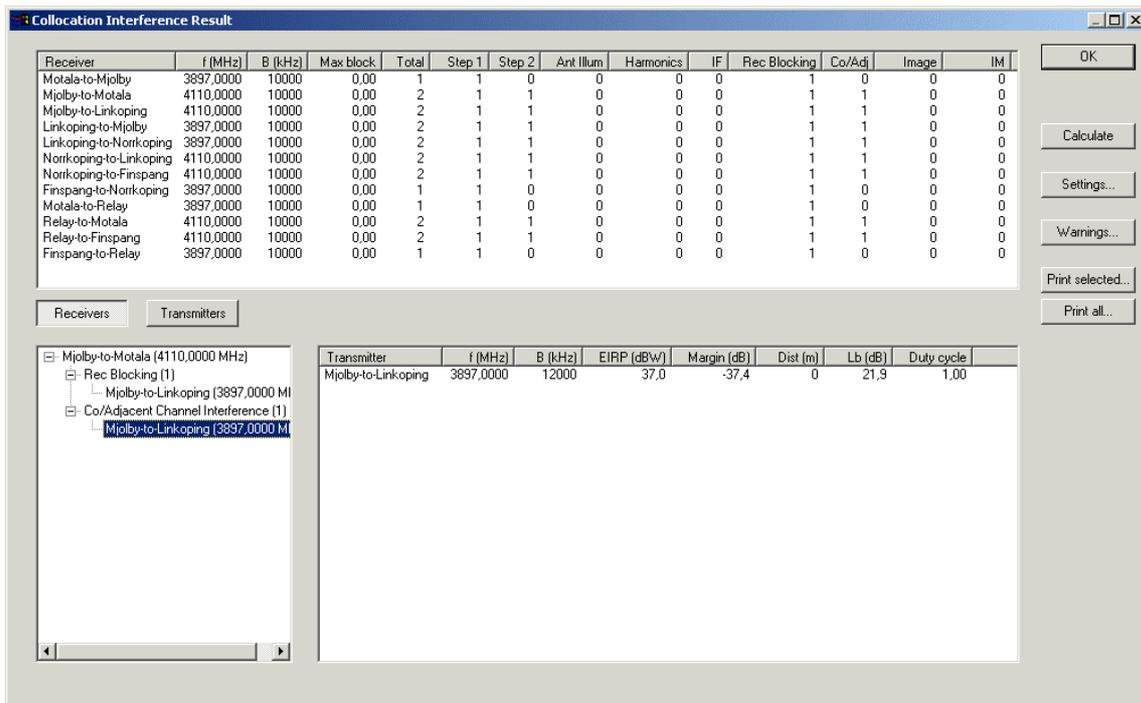
### CHECKING FOR COLLOCATION INTERFERENCE

There may be a risk for interference if the new stations are located near existing radio installations. This may give rise to interference such as intermodulation, harmonics etc.

Analysis of this can be performed with the  **Collocation Interference** tool. The normal procedure would be to search for other stations in the vicinity of each of the new installations and add these to the project.

Run the **Collocation Interference** tool just to illustrate the procedure. Perform the following:

- Mark all stations in the project. Start the  **Collocation Interference** tool.
- The main window opens. Press **Calculate** (you may naturally study the settings).
- Maximise the window after the calculation has been performed. Mark the second receiver in the top list box. Then expand the view in the bottom left list box by clicking on the + sign. Mark the line as shown below. The "Margin" value indicates the sensitivity degradation, in this case due to interference from the other transmitter at the same location. Since the wanted signal level is high this degradation is negligible.



The screenshot shows the 'Collocation Interference Result' window. It contains a table with the following data:

Receiver	f (MHz)	B (kHz)	Max block	Total	Step 1	Step 2	Ant Illum	Harmonics	IF	Rec Blocking	Co/Adj	Image	IM
Motala-to-Mjolby	3897.0000	10000	0,00	1	1	0	0	0	0	1	0	0	0
Mjolby-to-Motala	4110.0000	10000	0,00	2	1	1	0	0	0	1	1	0	0
Mjolby-to-Linkoping	4110.0000	10000	0,00	2	1	1	0	0	0	1	1	0	0
Linkoping-to-Mjolby	3897.0000	10000	0,00	2	1	1	0	0	0	1	1	0	0
Linkoping-to-Norrkoping	3897.0000	10000	0,00	2	1	1	0	0	0	1	1	0	0
Norrkoping-to-Linkoping	4110.0000	10000	0,00	2	1	1	0	0	0	1	1	0	0
Norrkoping-to-Finspang	4110.0000	10000	0,00	2	1	1	0	0	0	1	1	0	0
Finspang-to-Norrkoping	3897.0000	10000	0,00	1	1	0	0	0	0	1	0	0	0
Motala-to-Relay	3897.0000	10000	0,00	1	1	0	0	0	0	1	0	0	0
Relay-to-Motala	4110.0000	10000	0,00	2	1	1	0	0	0	1	1	0	0
Relay-to-Finspang	4110.0000	10000	0,00	2	1	1	0	0	0	1	1	0	0
Finspang-to-Relay	3897.0000	10000	0,00	1	1	0	0	0	0	1	0	0	0

Below the table, there are tabs for 'Receivers' and 'Transmitters'. The 'Receivers' tab is active, showing a tree view of the selected receiver 'Mjolby-to-Motala (4110.0000 MHz)'. The tree view is expanded to show 'Co/Adjacent Channel Interference (1)', which contains a sub-entry 'Mjolby-to-Linkoping (3897.0000 M)'. To the right of the tree view is a table with the following data:

Transmitter	f (MHz)	B (kHz)	EIRP (dBW)	Margin (dB)	Dist (m)	Lb (dB)	Duty cycle
Mjolby-to-Linkoping	3897.0000	12000	37,0	-37,4	0	21,9	1,00

## FREQUENCY ASSIGNMENT

The interference check showed that every link in the network operates satisfactorily with the first attempt to assign frequencies. This was such a simple case, requiring little or no support in the selection of frequencies. An automated method of frequency assignment should be used when it is difficult to find suitable frequencies. This is done with the **F+** **Frequency Assignment** tool. This tool also gives a convenient graphic display of the interference situation for each station to support manual frequency assignment. You can try this out in the following way:

- Mark all stations that should have transmitter frequency in the low band (for automatic assignment). To study the interference situation, just mark all stations. Start the **F+** **Frequency Assignment** tool.
- First an appropriate channelling plan must be selected. Click on **Raster - Select Raster**. Choose the **4 GHz, 14,5 MHz, 213 MHz** raster and click on **OK**.
- Now select **Blocking - Settings**. Select the **ITU-R P.526** propagation model. Click on **OK** and then **OK** in the Blocking Settings window.
- Select **Blocking - Calculate**. The list views become white when the calculation is ready. Mark the **Station Name** for each station in the upper left list view. This will display the margin diagram that gives information on the assignment margins.
- The assignment can be changed manually by clicking on the vertical lines. The colours indicate the following:
  - Blue: Already in use by the marked station
  - Yellow: Assignable
  - Red: Not assignable (due to non-fulfilment of signal-to-interference criteria).
- Frequencies can be removed by right-clicking and selecting whether to delete just this frequency or all frequencies. Before performing a complete automatic assignment it is common practice to delete all frequencies.
- Automatic assignment can be performed by selecting **Automatic - Start**. There are several settings to control the assignment algorithm in the **Automatic - Settings** menu.

**Finally: Save the link stations to the station database. This is done by marking all stations, right-clicking and selecting Save.**

---

## EXERCISE 2: EARTH STATION COORDINATION

---

Many frequency bands in the microwave range are shared between fixed services and various satellite and space services. The ITU prescribes that a specific coordination procedure shall be performed to secure the compatibility between space and fixed services. The procedure is illustrated in the following.

The ITU publishes the Space Radiocommunication Stations on CD-ROM and regular updates through one of the BR IFIC CD-ROMs. There is associated software to search for earth stations and satellites to allow analysis of interference and to initiate, if needed, a coordination procedure.

A search was made to find a receiving earth station with which there may be a need to coordinate since its frequency use is overlapping with the 3897 MHz frequency of the link network that we just planned. The earth station NIT 5 is located in Norway, receiving the satellite Intelsat 5 Indo C1 at 63 degrees east in the geostationary orbit.

After establishing that a frequency overlap exists the particular data for this earth station was entered in WRAP and stored in a project. The satellite was created and stored under the name Intelsat 5 Indo C1. Now perform the following to calculate the coordination area around earth station NIT 5:

- Open the project **NIT5.WPR** in the `...\WRAP\Samples` folder. (You should close the previous link project first).

This project uses another geographical database, the GTOPO30. This is a world-wide database having height information in a raster with 30 seconds resolution (about 900 metres in north-south direction, 900 m or less in east-west direction) and a terrain classification of “land” and “sea”. The link network that was created in the previous exercise has been included in this project.

- Show the stations in the project in the list view. Show NIT 5 on the map. Mark NIT 5 and select the  **Earth Station Coordination** tool.
- Make the following settings:
  - Exceed time RX: 0.01 %
  - Radiation pattern: 6
  - Rx Ant Gain: 54 dBi (data from the SRS CD-ROM)
  - Climate zone: Use IDWM (ITU Digitized World Map)
  - Geometry: Calculate (means that the terrain mask will be derived from the GTOPO30 database.
  - Effective earth radius factor: 1.33
  - Maximum terrain height: 1000 m
  - Number of auxiliary contours: 0
  - Description: A suitable name for the calculation.

- Click **OK** to start the calculation and close the window.
- The result will appear in the folder **This Project\Results\Earth Station Coordination Results**. Double-click on the result name to open the **Edit result** window.
- Select the **Results** tab. Check all three contours for display. Select thicker lines and nice colours to display well on the map. Press **OK**.
- Right-click on the result name and select **Visible**. The map now shows three contours.
  - Circle: Propagation mode 2 (rain scatter)
  - Irregular: Propagation mode 1 (tropospheric)
  - Circle + Irregular: The maximum distance of the two above.
 The coordination contour is given by the maximum distance from the earth station, so the separate displays of Mode 1 and Mode 2 can be removed.

Show all the stations on the map and notice that all the links are within the contour, thus requiring the coordination procedure to be performed. The next step is to calculate the interference contribution in the earth station from the link transmitters that operate within the frequency band of the earth station. This is done with the Interference tool.

Perform the following:

- Mark the **NIT 5** station. Start the  **Interference** tool.
- Make the following settings:
  - Propagation model, Interferer: ITU-R P.452
  - Propagation model, Wanted: Not applicable. Use Free-space
  - Interference level: I [dBm] Above -170 dBm
  - Interference level: S/I Below 50 dB
  - ITU-R P.452 settings: Clear air, 0.01 %, Worst month. Default for other settings.
- Close the windows with **OK** to start the calculation. Notice that the interference level is very low (about -156 dBm). You may also try with the hydrometeor.scatter model.

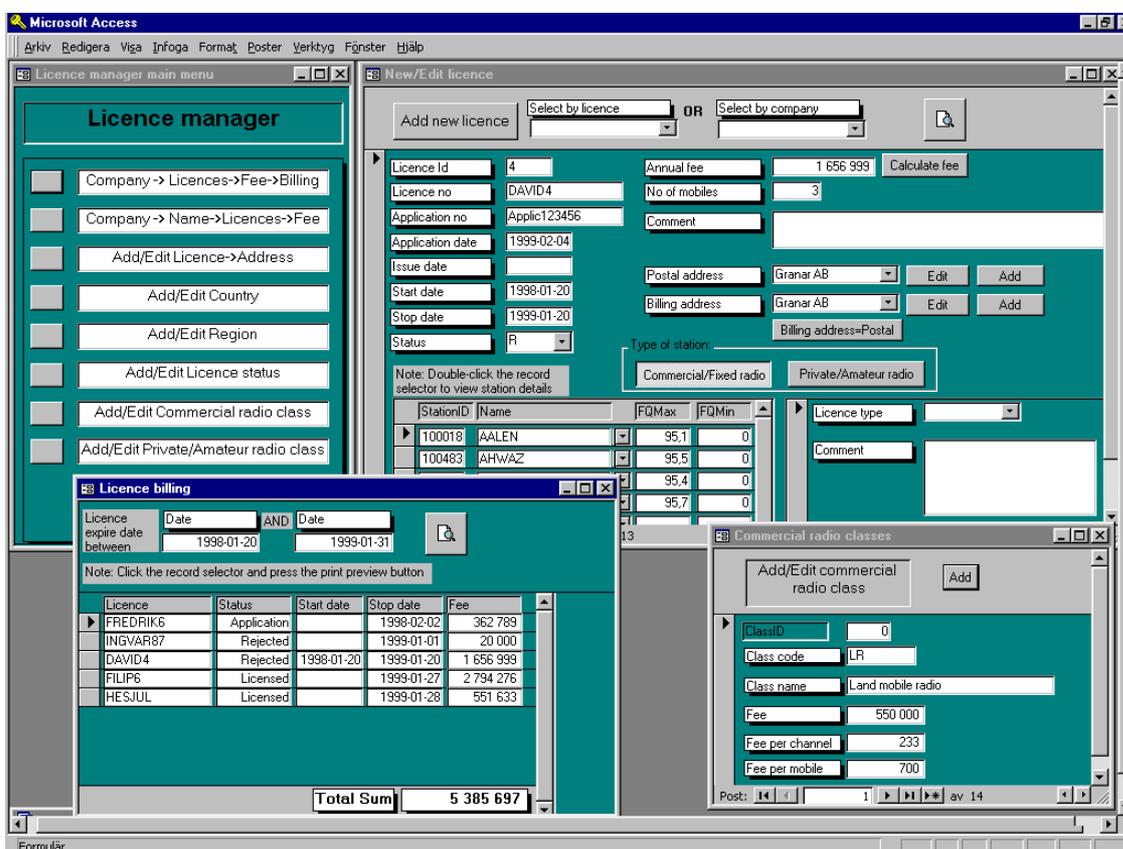
The resulting interference level is very low, far below the sensitivity of the earth station. This should mean that the links would pass the coordination procedure with Norway without problems.

## EXERCISE 3: LICENSING

Licences are handled in a separate application, the WRAP Licence Manager. This application operates on the same station database as the technical system, meaning that it can retrieve required technical data from the database and add various administrative data associated with the station(s) to be licensed.

Perform the following to start the Licence Manager:

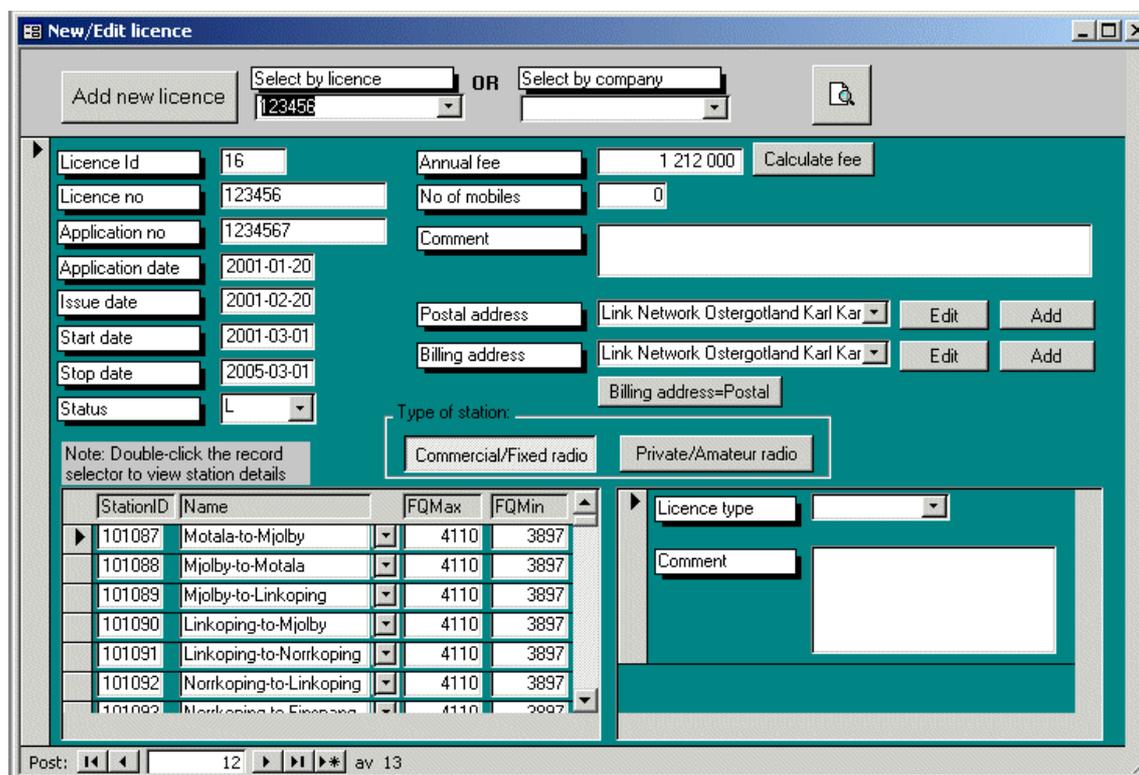
- Select (Windows start menu) **Start - Programs - WRAP Licence Manager - WRAPLicMan**. This opens a main menu, where several selections can be made. Some of the available functions are shown in the collection below:



- Click on the box left of **Add/Edit Licence -> Address**. This opens a window, which is used to generate a new licence and, if needed, a new licensee address.
- Click on **Add new licence**. This clears the entry fields and allows new data. Fill in reasonable data (details are not important for this exercise). Note that an entry first has to be made in the **Licence no** field. Otherwise it is not possible to enter data in the other fields.

- All of the stations in the new network generated in the first exercise can be licensed in one form. Selection of stations is done by clicking on the **drop-down arrow** just right of the entry field "**Name**". This opens a list of all non-licensed stations in the database. Selection of station is easily performed either by scrolling the list or by entering the first few characters of the station name. This caused automatic search for these first characters.
- Select all of the station in the new network.
- Licensee addresses that already exist can be selected by clicking on the **drop-down arrow** just right of the **Postal Address/Billing Address fields**. New addresses can be entered by clicking on **Add**.
- When all stations have been entered you can click on **Calculate fee**. This will calculate the total licence fee for this licence, based on the fee structure that has been defined. The fee structure can be edited in the **Edit commercial radio class** function that can be selected from the main menu.

Having entered complete data into the form gives (for example) the following view:



The screenshot shows the 'New/Edit licence' window with the following fields and data:

- Add new licence** button
- Select by licence** dropdown: 123456
- Select by company** dropdown
- Calculate fee** button
- Licence Id**: 16
- Annual fee**: 1 212 000
- Licence no**: 123456
- No of mobiles**: 0
- Application no**: 1234567
- Application date**: 2001-01-20
- Issue date**: 2001-02-20
- Start date**: 2001-03-01
- Stop date**: 2005-03-01
- Status**: L
- Postal address**: Link Network Ostergotland Karl Kar
- Billing address**: Link Network Ostergotland Karl Kar
- Type of station**: Commercial/Fixed radio (selected), Private/Amateur radio
- Station list table:**

StationID	Name	FQMax	FQMin
101087	Motala-to-Mjolby	4110	3897
101088	Mjolby-to-Motala	4110	3897
101089	Mjolby-to-Linkoping	4110	3897
101090	Linkoping-to-Mjolby	4110	3897
101091	Linkoping-to-Norrkoping	4110	3897
101092	Norrkoping-to-Linkoping	4110	3897
101093	Norrkoping-to-Eingevad	4110	3897
- Licence type** dropdown
- Comment** text area
- Post:** 12 av 13

- Now click on the **Print Preview** button in the upper right part of the form. This opens a preview window, where the licence information as it may be printed appears.

There are several functions available for editing basic data that then can be selected from drop-down lists. These are available in the first window – the Main Menu.

Data generated in the licensing process are stored in the station database and can be retrieved later.

---

## EXERCISE 4: COORDINATION AND NOTIFICATION

---

This exercise deals with the coordination and notification process that is necessary in many instances. The rules for when coordination and notification are required can be found in the ITU Radio Regulations.

A result of the first exercise was that the coordination contour (receiving) around the Norwegian earth station NIT 5 extended to include all the radio link stations that were planned in the exercise. Some of them transmit on an overlapping frequency assignment. This means that coordination should be performed with the Norwegian telecommunications administration. After successful coordination a notification on the coordinated link stations should be sent to the ITU BR (Bureau of Radiocommunications) for entry in the master international frequency register.

The handling of the notification process is supported by the WRAP Licence Manager. Perform the following to illustrate how this is done.

- Start the Licence Manager. Select the item **Coordination** on the main menu.
- Study the form that opens. There is a fly-by information that appears when the cursor is positioned on each of the available T-series notification forms (as they are defined by the ITU). Click on the **drop-down arrow** for the **Not coordinated stations**. This opens a list of stations in the database. Enter the first letter of the station to be coordinated (in this case one of the stations that operate on 3897 MHz). Select that station.
- The proper form is **T11**. Select this one to open the form. Data that were already available in the database are filled automatically in the form. Other data must be entered manually.

- Some notes referring to the form that now is displayed:
  - Shaded fields are only applicable in certain cases
  - Fields that are automatically filled from the database are read-only. Data in these can only be changed from the technical WRAP system.
  - Fields with a drop-down button are filled from selections that are made from the drop-down list.
  - The T11 form can only handle the notification of one station with one frequency
  - The Administration Unique Identifier is an important field. The format here is obviously defined by the administration submitting the notification.
  - Field 7b takes values A, B and C but is only mandatory for the fixed service in the HF frequency range.
  - Field 9ea is not filled automatically in the current version. The altitude above sea level can be found in the technical system by placing the cursor at the station and reading the altitude in the status bar.
  - S6.7 should be entered in Field 11 should for this particular case. **NOR** (Norway) should be selected from the drop-down list, since we assume that the station was successfully coordinated with the Norwegian administration.
  - Field 9c is not filled automatically in the current version. The correct value can be found by opening the **Edit Station** window, select **Antenna - Edit** and reading the 3 dB-beamwidth from the table of values. It is in this case about 2 degrees.
  - Data for fields 12a and 12b may be a little complicated to find. Information is available in for instance ITU documents and software. Enter A in field 12b and for instance 660 in field 12a.
  - Field 5g is not entered automatically in the current version. This is the distance between the transmitter and its associated receiver at the other end. Can be found by using the **Calculation/Search area - Line** in the technical system. Position the start of the line at the transmitter and the end at the receiver. Read the distance in the status bar.

Detailed information on the fields in the notification forms can be found in Ref 27 in the WRAP References document in the **UsersGuide\References** folder.

- Click on **Save** when all desirable information has been entered. This will save the entry for later retrieval for printing or continued work in the notification process.

The Coordination form now should display a line for the just completed T11 notification. Marking this line and clicking on **Show** will display the stored form for viewing and printing.

A change to a notification that has been submitted as and **Addition** (i. e. for a new entry to the ITU BR) is notified by using the **MOD (Modification)** function.

Deletion of an existing entry in the master international frequency register is performed by the **SUP (Suppress)** function.

Withdrawal of a notification (ADD or SUP) is done with the **WITHDRAW** function.

The history of submissions for a particular station can be viewed by selecting a station of interest from the drop-down list that is seen when selecting that station in the list **Previously coordinated stations**.

The just completed T11 notification may look as follows when viewed with the **SHOW** function:

Date of notification Day Month Year 13 02 2001		B: Notifying Administration S		Notification intended for of an assignment (For BR use only)		ADD <input checked="" type="checkbox"/> MOD <input type="checkbox"/> SUP <input type="checkbox"/>		FORM OF NOTICE TERRESTRIAL TRANSMITTING STATION (TX) IN THE FIXED SERVICE (APPENDIX S4, ANNEXES 1 A AND 1B)				T11									
Submission under the provisions of RR S11.2 <input type="checkbox"/> S9.21 <input checked="" type="checkbox"/>		First notification <input checked="" type="checkbox"/>		Re-submission <input type="checkbox"/>		Withdrawal of notice <input type="checkbox"/>		Administration Unique Identifier SE21436512				Previously recorded Administration Unique Identifier									
Other identifying information (for MOD / SUP only) - previously recorded data (if changed)																					
0-1a: Assigned frequency k/M/G Hz		0-5a: Class of station		0-7a: Designation of emission		0-7b: Class of operation (A/B/C)		0-10b: Hours of operation From (UTC) To (UTC)		0-4c: Coordinates (Longitude / Latitude) deg. min. sec. E/W deg. min. sec. N/S											
Particulars of the assignment																					
1a: Assigned frequency k/M/G Hz		1b: Reference (carrier) frequency k/M/G Hz		3a: Class of station		3b: Nature of service		7a: Designation of emission		7b: Class of operation (A/B/C)		10b: Hours of operation From (UTC) To (UTC)		7e: Frequency deviation (MHz)		7f: Energy dispersal (kHz)					
2a: Date of bringing into use Day Month Year		3a: Call Sign or Station identification (RR S19)																			
4a: Name of the location of the transmitting station				4b: Geographic area		4c: Coordinates (Longitude / Latitude) deg. min. sec. E/W deg. min. sec. N/S				4e: Altitude of site above sea level											
11: Successfully completed coordination with other Administrations Provision Symbols designating the Administration																12a: Operating agency		12b: Address code of Administration		Other information (supplied on a separate sheet)	
8: Type of power		8a: Power to the antenna (+/-) (dBW)		8b: Radiated power (+/-) (dBW) (E/V)		8ab: Maximum power density (+/-) (dBW/MHz)															
9: Directivity of the antenna		9a: Azimuth (deg.)		9ab: Azimuthal sector for rotating antenna (deg. from) (deg. to)		9c: Beamwidth (deg.)		9g: Max. gain (Type) (dB)		9j: Reference antenna		9b: Elevation angle (+/-) (deg.)		9d: Polarization code		9e: Height above ground level					
5a: Name of the location of the receiving station(s)				5b: Geographic area		5c: Coordinates (Longitude / Latitude) deg. min. sec. E/W deg. min. sec. N/S				9k: Receiving system noise temperature (K)		5g: Maximum length of the circuit (km)									