Harmonized Calculation Method
Fixed Service

Developed by the Sub Working Group Program
Revision 10
04/2013

Contents

1. GENERAL

This Harmonized Calculation Method for the Fixed Service (HCM-FS) is part of the HCM-Agreement (Zagreb 2010). It deals with fixed point-to-point links, which may include one passive back-to-back antenna repeater. The total threshold degradation (TD) in case of links with passive repeaters is a combination of direct and indirect (via repeater) propagation paths. Calculations for plane reflector repeaters are not covered by the HCM-Agreement.

HCM-FS software generally consists of two parts – the calculation library (HCMFS_DLL) and the program (CalcFiSH). All calculations are being made in the calculation library. CalcFiSH does not make HCM calculations by itself; instead it uses the library for calculations. This document will describe both – the calculation library and the program. Although HCM-FS is generally developed for Microsoft Windows operating system, it may also be compiled for Linux. In case calculation result for Microsoft Windows differs from the one on Linux, the Windows version of HCM-FS will be the reference.

General note:

In this description (unless stated differently):

all angles are in degrees,

all heights are in metres,

all distances are in kilometres,

and

"Annex to the HCM-Agreement" is the Annex to the HCM-Agreement (Zagreb 2010).

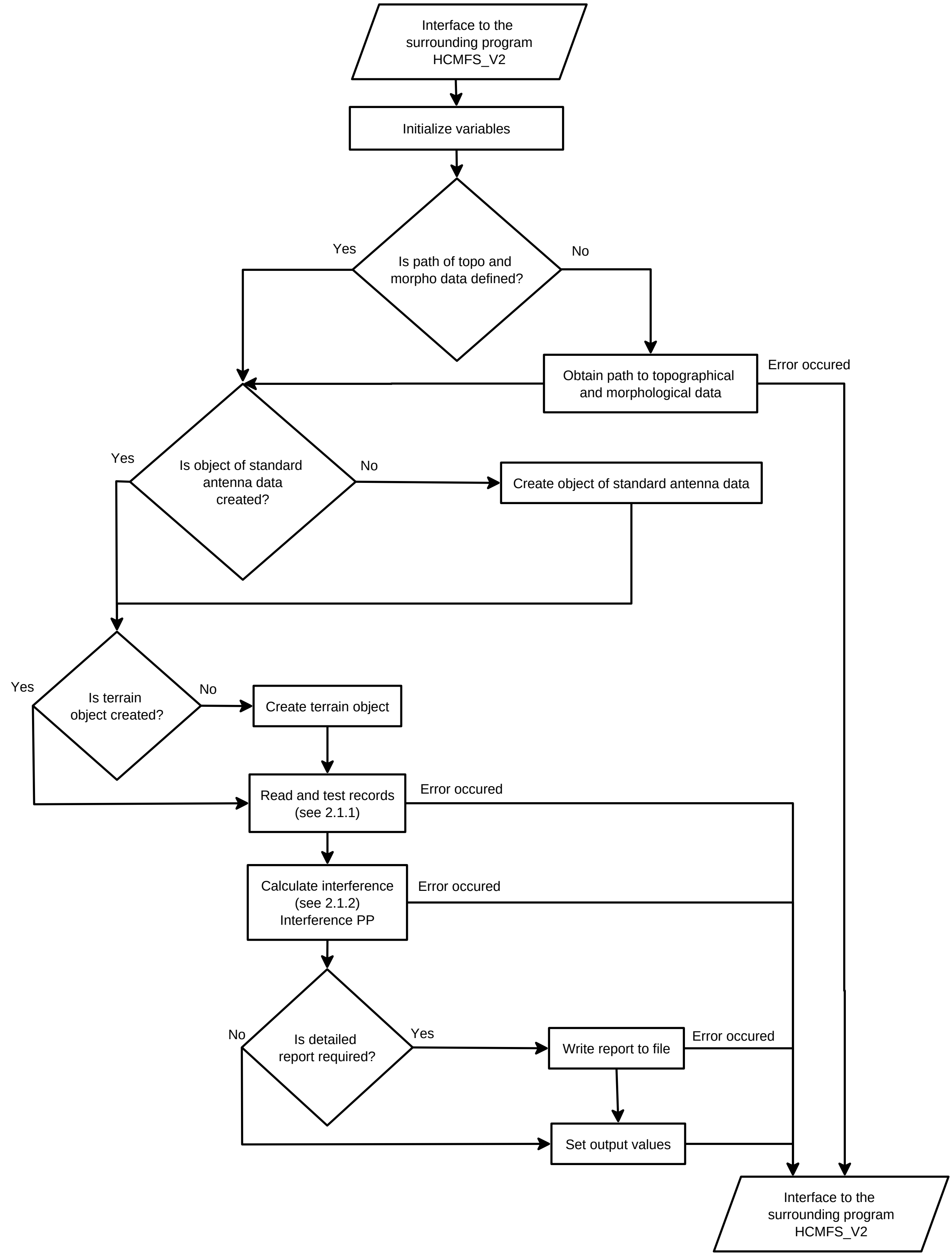
2. CALCULATION LIBRARY HCMFS_DLL

Due to the platform specific issues calculation library compiled for Microsoft Windows has a different name that one compiled for Linux. Windows file name is HCMFS_DLL.dll while Linux file name is libhcmfs.so.xxx, where xxx represents library version.

Calculation library performs two types of calculations:

- Interference calculations. The main output parameter is Threshold degradation (TD).
- Calculations of co-ordination trigger, performed according to Annex 11 to the HCM-Agreement. This may help the administrations to decide if stations require co-ordination. The main output parameter is name of countries to coordinate with.

2.1 HCM-FS INTERFERENCE CALCULATION SUBROUTINE HCMFS_V2


Interface to the surrounding program HCMFS_V2
Initialize variables
Is path of topo and morpho data defined?
Yes
No
Obtain path to topographical and morphological data
Error occured
Is object of standard antenna data created?
Yes
No
Create object of standard antenna data
Is terrain object created?
Yes
No
Create terrain object
Read and test records (see 2.1.1)
Error occured
Calculate interference (see 2.1.2) Interference PP
Error occured
Is detailed report required?
No
Yes
Write report to file
Error occured
Set output values
Interface to the surrounding program HCMFS_V2

Interface to the surrounding program HCMFS_V2

```
HCMFS_V2(double &I_O_AREA, float &I_NFD, float &I_MD, float &I_I,
         float &I_A_TOT, float &I_TD, long &I_Error, const char* I_Record1,
         long L1, const char* I_Record2, long L2, const char* I_Record3 ,
         long L3, const char* I_Record4, long L4, const char* I_DLL_textfile,
         long Lfile, const char* I_Drive, long LDrive)
```

Output parameters:

I_O_AREA	overlapping area
I_NFD	NFD value
I_MD	MD value
I_I	interference level
I_A_TOT	total attenuation
I_TD	threshold degradation
I_Error	error value

Input parameters:

I_Record1	Tx data according to ANNEX 2B
L1	length of I_Record1. Required for compatibility with old dll
I_Record2	Rx or PRx data according to ANNEX 2B
L2	length of I_Record2. Required for compatibility with old dll
I_Record3	PTx data according to ANNEX 2B or empty
L3	length of I_Record3. Required for compatibility with old dll
I_Record4	Rx data according to ANNEX 2B or empty
L4	length of I_Record4. Required for compatibility with old dll
I_DLL_textfile	optional. Filename of an output file. Not calculated values appear in the file having values = -2222. This is not an error. This may happen when overlapping area = 0. In this case some parameters are not calculated and have value of NO DATA, which is -2222.
Lfile	length of I_DLL_textfile. Required for compatibility with old dll
I_Drive	drive letter of the drive containing TOPO, MORPHO and BORDER directories, or empty (see Requirements). For Linux this parameter is not used and can be left empty.
LDrive	length of I_Drive. Required for compatibility with old dll

Requirements

PATH.DAT or Registry keys	FOR WINDOWS ONLY. If I_Drive is empty, program searches for the file PATH.DAT in the directory where HCMFS_DLL.DLL is located. PATH.DAT was introduced in DLL version 2.3.0.0 and higher and is of the same format as it is required by HCM MS Program. The file specifies directories where topological, morphological,

	and border data is located. The purpose of introduction of the file is to enable user with no administrative rights to define location of such data other than the root folder of a hard disk. The content of PATH.DAT could be as follows: Topo = Z:\data\topo Morpho = D:\morphological_data Border = C:\border If PATH.DAT does not exists program searches for topological, morphological, and border paths in Windows registry. Following registry keys should be available: HKEY_LOCAL_MASHINE\Software\HCM\topo (SZ type). Mandatory if I_Drive is empty and path.dat does not exists. Contains path of topological data. HKEY_LOCAL_MASHINE\Software\HCM\morpho (SZ type). Optional. Contains path of morphological data. HKEY_LOCAL_MASHINE\Software\HCM\border (SZ type). Mandatory for Annex 11 calculations if I_Drive is empty and path.dat does not exist. Contains path of border data.
/etc/hcmrc or ~/.hcmrc	FOR LINUX ONLY. Parameter file. Mandatory for Linux. Contains paths of TOPO, MORPHO, BORDER directories. The file should contain following variables: TOPO - directory of topological data (mandatory), MORP - directory of morphological data (optional), BORD - directory of border data (required only for Annex 11 calculations only). Example of the file content: TOPO= /usr/local/topological_data MORP= /usr/local/morphological_data BORD= /usr/local/border_data
Topological data	Topological data in the HCM format. Mandatory. Data has to be placed into TOPO directory (if I_Drive contains drive letter), into the directory specified by PATH.DAT or the registry key (for Windows), or the parameter file (for Linux).
Morphological data	Morphological data in the HCM format. Optional. Data has to be placed into MORPHO directory (if I_Drive contains drive letter), or into the directory specified by PATH.DAT or the registry key (for Windows), or the parameter file (for Linux).

Initialize variables

In this part output variables are set to zero and some other parameters are initialized.

Is path of topo and morpho data defined?

Program checks if the paths of topological and morphological data are set. When HCM calculation library (DLL) is loaded and the first calculations are about to be made these paths remain unset. Therefore it redirects to the subroutine which tries to obtain them. After obtaining it they remain set until DLL is unloaded.

Obtain path to topological and morphological data

For Windows

If drive letter is submitted to HCMFS_V2 interface (parameter I_Drive) then paths are set to:

Drive letter:\TOPO

Drive letter:\MORPHO

If drive letter is not submitted to HCMFS_V2 then program searches for the file PATH.DAT in the same directory where HCMFS_DLL.DLL is located. PATH.DAT can have three parameters: *Topo*, *Morpho*, and *Border* (for this interface it is not used) as follows:

```
Topo = Z:\data\topo
Morpho = D:\morphological_data
Border = C:\border
```

Topo defines path to topographical data, *Morpho* defines path to morphological data, while *Border* defines path to border line data.

If file PATH.DAT is not found program searches Windows registry for the keys

HKEY_LOCAL_MASHINE\Software\HCM\topo,

HKEY_LOCAL_MASHINE\Software\HCM\morpho,

and sets appropriate paths accordingly.

If neither drive letter nor registry keys are present program sets appropriate error code.

For Linux

Program does not look at parameter I_Drive. It searches for file .hcmrc in the HOME folder of the current user. If the file does not exist it looks for the file /etc/hcmrc. If it is not present program sets an error. If the program finds the file it reads it and searches for the parameters TOPO and MORPHO, then sets appropriate paths accordingly.

An example of hcmrc file:

TOPO= /usr/local/topological_data

MORP= /usr/local/morphological_data

BORD= /home/Thomas/hcm/border_data

Is object of standard antenna data created?

When DLL is loaded object of standard antenna is not available. It must be created. When created it remains until DLL is unloaded.

Create object of standard antenna data

When object is being created it loads data from an array to the format of std::vector. When created it remains until DLL is unloaded.

Is terrain object created

When DLL is loaded terrain object is not available. It must be created. When created it remains until DLL is unloaded.

Create terrain object

When terrain object is being created it receives paths of topographical and morphological data for the future use. When object is created it remains until DLL is unloaded.

Test and read records

Program reads TX, RX, PTX, PRX data, converts numerical values to integer or floating point numbers and tests them. If an error occurs program stops. See 2.1.1 Test and read records for more details.

Calculate interference "InterferencePP"

InterferencePP is the main function which makes all the interference calculations. It is described in 2.1.2 Interference calculations.

Is detailed report required?

If I_DLL_textfile contains file name then detailed calculation report will be produced and written to the file.

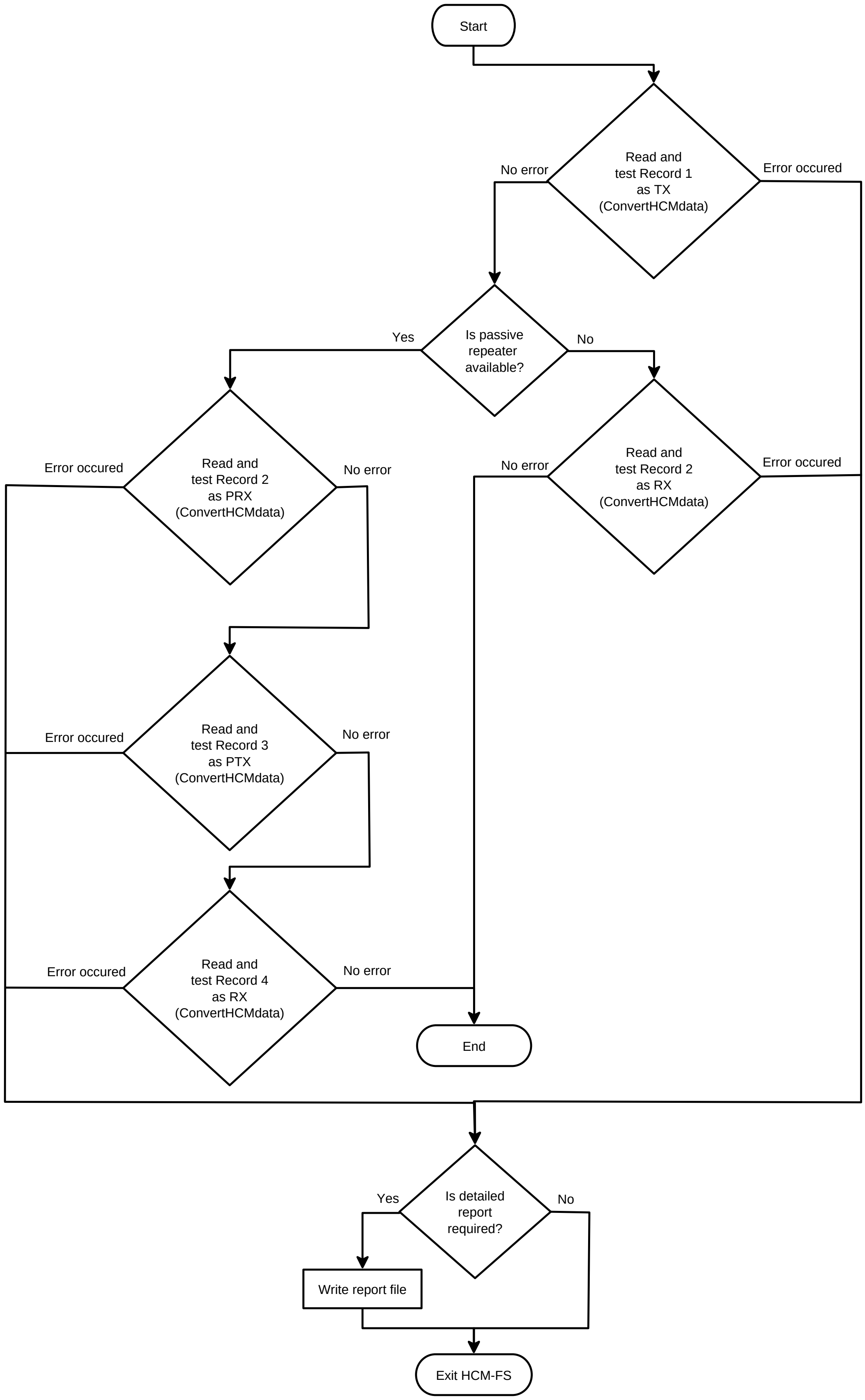
Write report file

This writes all available calculation data to the report file specified by I_DLL_textfile. If file name contains error or HCMFS_DLL does not have rights for writing, it will produce an error and stop.

Set output values

This will set output parameters.

2.1.1 Test and read records


Start
Read and test Record 1 as TX (ConvertHCMdata)
No error
Error occured
Is passive repeater available?
Yes
No
Read and test Record 2 as PRX (ConvertHCMdata)
Error occured
No error
Read and test Record 2 as RX (ConvertHCMdata)
No error
Error occured
Read and test Record 3 as PTX (ConvertHCMdata)
Error occured
No error
Read and test Record 4 as RX (ConvertHCMdata)
Error occured
No error
End
Is detailed report required?
Yes
No
Write report file
Exit HCM-FS

Reading and testing of the records is rather straightforward. A function ConvertHCMdata converts a record formatted according to Annex 2B to the HCM-Agreement to the appropriate data structure. If subroutine finds out that no passive repeater is available then it reads first two records (I_Record1 and I_Record2. See 2.1 HCM-FS INTERFERENCE CALCULATION SUBROUTINE HCMFS_V2 for more details). In case of error it writes detailed report to the file, if necessary, and stops. If passive repeater is available the function will convert all four records. In case of error subroutine will act the same way as without passive repeater.

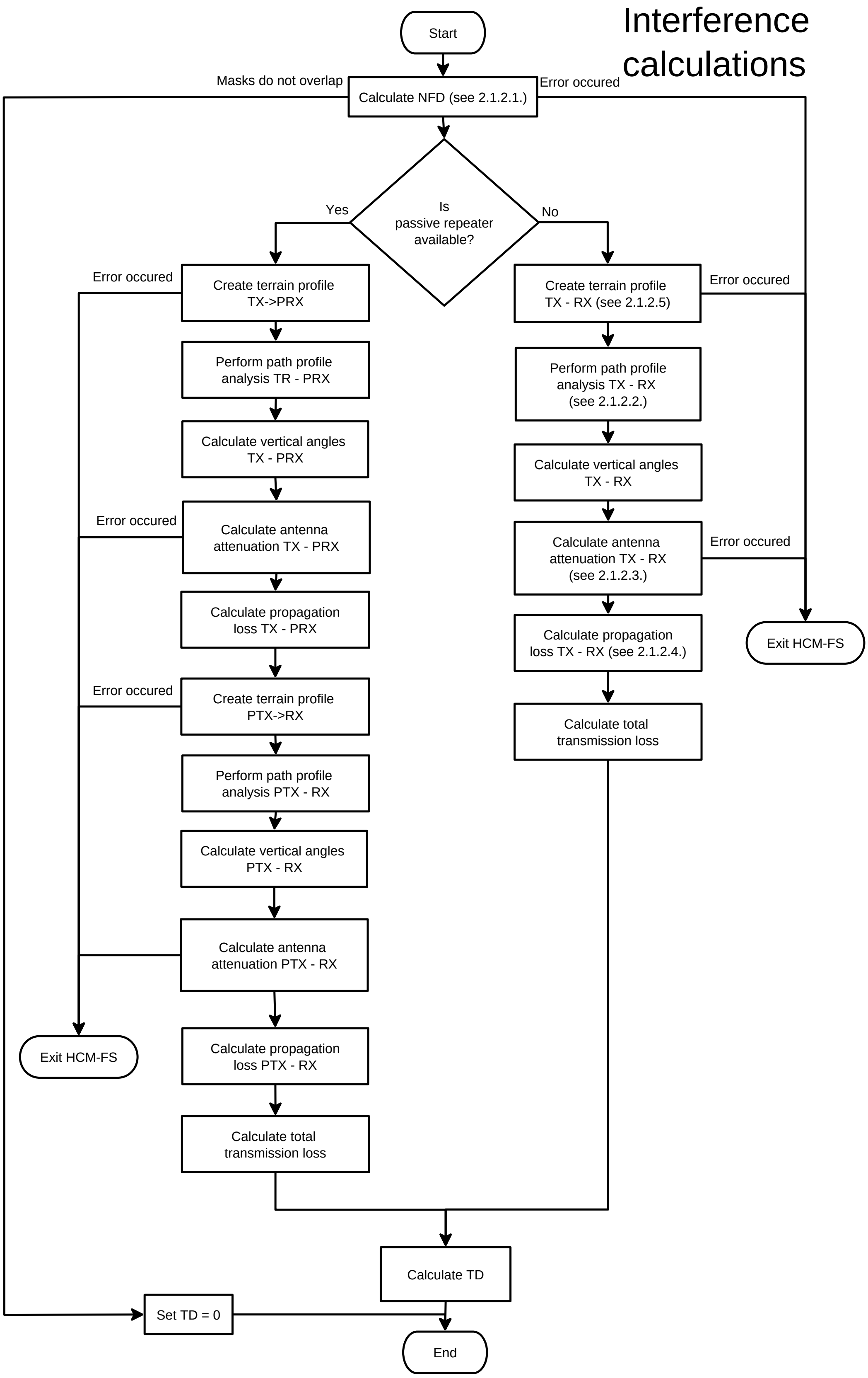
Record 1 always has to contain TX data.

Record 2 has to contain PRX data in case of passive repeater, or RX data in case repeater is not available.

Record 3 has to contain PTX data in case of passive repeater, otherwise it should be left blank.

Record 4 has to contain RX data in case passive repeater is available, otherwise it should be left blank.

2.1.2 Interference calculations


Interference calculations
Start
Masks do not overlap
Calculate NFD (see 2.1.2.1.)
Error occured
Is passive repeater available?
Yes
No
Error occured
Create terrain profile TX->PRX
Perform path profile analysis TR - PRX
Calculate vertical angles TX - PRX
Error occured
Calculate antenna attenuation TX - PRX
Calculate propagation loss TX - PRX
Error occured
Create terrain profile PTX->RX
Perform path profile analysis PTX - RX
Calculate vertical angles PTX - RX
Calculate antenna attenuation PTX - RX
Exit HCM-FS
Calculate propagation loss PTX - RX
Calculate total transmission loss
Create terrain profile TX - RX (see 2.1.2.5)
Error occured
Perform path profile analysis TX - RX (see 2.1.2.2.)
Calculate vertical angles TX - RX
Calculate antenna attenuation TX - RX (see 2.1.2.3.)
Error occured
Exit HCM-FS
Calculate propagation loss TX - RX (see 2.1.2.4.)
Calculate total transmission loss
Calculate TD
Set TD = 0
End

Calculate NFD

In order to reduce calculation time NFD calculations are performed in the first place (function calcNfd). It includes calculation of overlapping area, NFD and MD. If overlapping area equals to zero it means that transmitter and receiver masks do not overlap and there is no interference in this case.

Is passive repeater available?

Presence of passive repeater makes calculations twice as long because of two different paths (TX -> PRX, PTX -> RX) that need to be studied. It is seen from the flowchart that there are several calculation parts that are common for every path and they do not depend on whether passive repeater is present or not. Therefore further only case without passive repeater will be explained more detailed.

Create terrain profile

For this purpose class TTerain is used. By supplying the class with TX and RX co-ordinates it produces profile and calculates distance and azimuth.

Perform path profile analysis

The analysis is performed in class TPropagation using function Init according to Chapter 5 of Annex 10 to the HCM-Agreement.

Calculate vertical angles

Annex 8B to the HCM-Agreement defines two different formulas for calculation of vertical angles between transmitter and receiver depending on path type which is estimated while analysing path profile. This is why path profile analysis is performed first.

Calculate antenna attenuation

Calculations of antenna attenuation between transmitter and receiver are performed according to Annex 8B to the HCM-Agreement using function calcA_ant. This function combines vertical and horizontal angles of transmitter and receiver.

Calculate propagation loss

Propagation loss is obtained using function Loss of the class TPropagation according to Chapter 6 of Annex 10 to the HCM-Agreement.

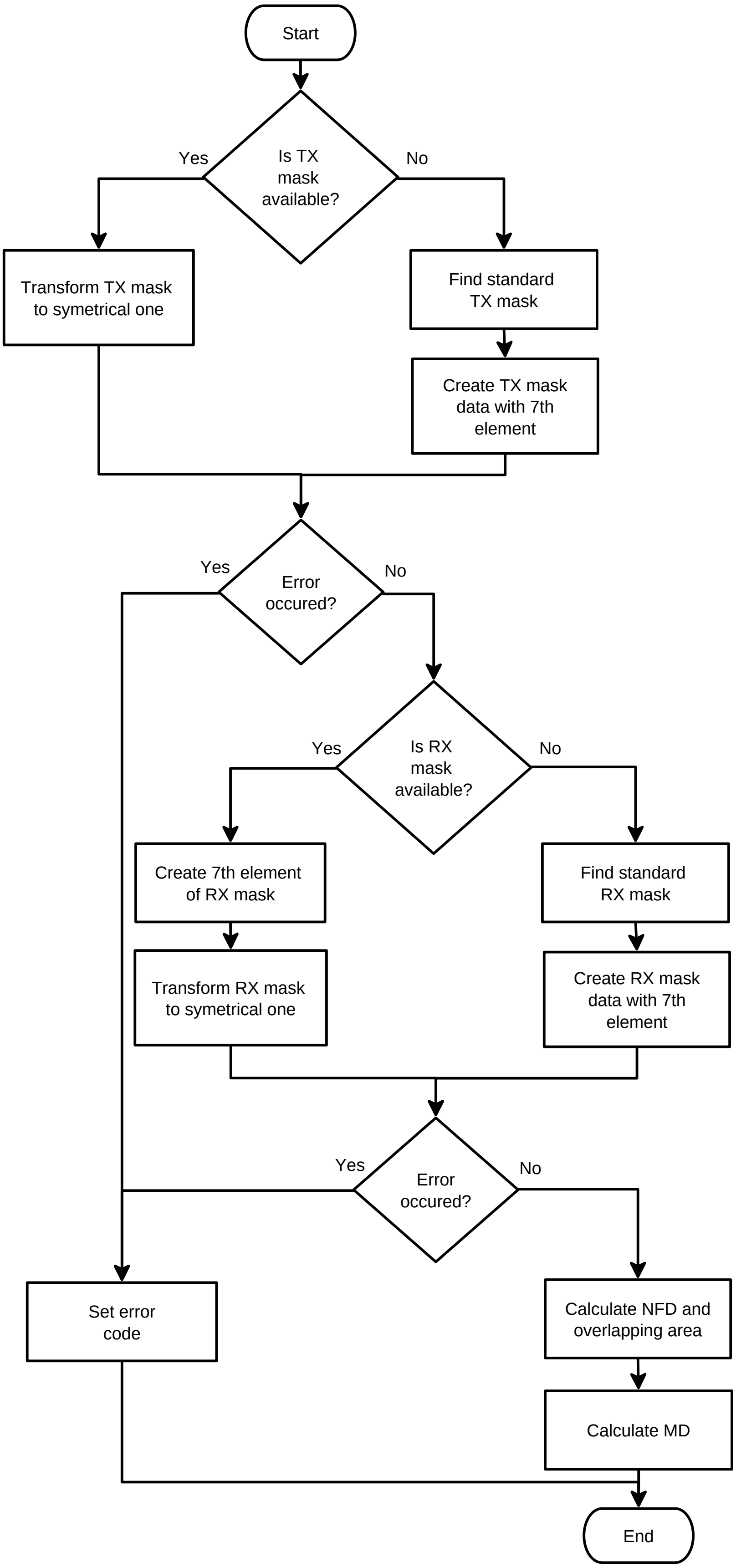
Calculate total transmission loss

The total transmission loss is calculated according to formulae 1.2 of the Annex 9 of the HCM-Agreement.

Calculate TD

Threshold degradation is calculated according to formulae 1.3 of the Annex 9 of the HCM-Agreement.

2.1.2.1 NFD calculations


Start
Is TX mask available?
Yes
No
Transform TX mask to symetrical one
Find standard TX mask
Create TX mask data with 7th element
Error occured?
Yes
No
Is RX mask available?
Yes
No
Create 7th element of RX mask
Transform RX mask to symetrical one
Find standard RX mask
Create RX mask data with 7th element
Error occured?
Yes
No
Set error code
Calculate NFD and overlapping area
Calculate MD
End

Is TX mask available

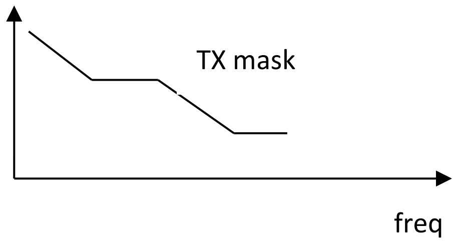
Program checks if TX has the spectrum mask available. If it does not have the mask, appropriate standard mask has to be chosen.

Create 7th element of TX mask

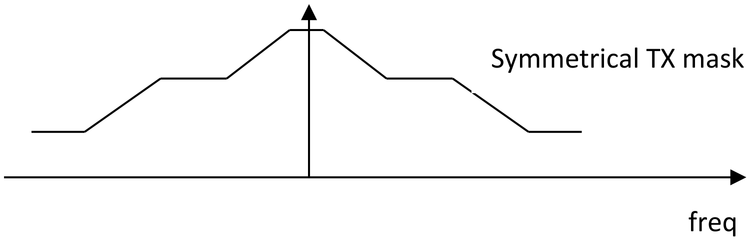
At this point program creates the last mask element with the *frequency = 2.5 x channel spacing* and the attenuation equal to the one of the last point.

Transform TX mask to symmetrical one

Annex 2B to the HCM-Agreement allows setting unsymmetrical mask only, as it is shown below.



Since calculations require a symmetrical mask we create one by mirroring unsymmetrical data.



Find standard TX mask

Program searches for standard TX mask according to its frequency band, equipment class, and channel spacing. If equipment class is not defined it looks for the mask with the lowest class and channel spacing greater or equal to the TX channel spacing.

Create TX mask data with 7th element.

When found, TX mask is converted to appropriate format with the 7th element added containing *frequency = 2.5 x channel* spacing and attenuation equal to the one of the last point.

Error occurred?

Program checks if error has occurred during the process of TX mask preparation.

Set error code

If the error has occurred program sets error code and exits the subroutine.

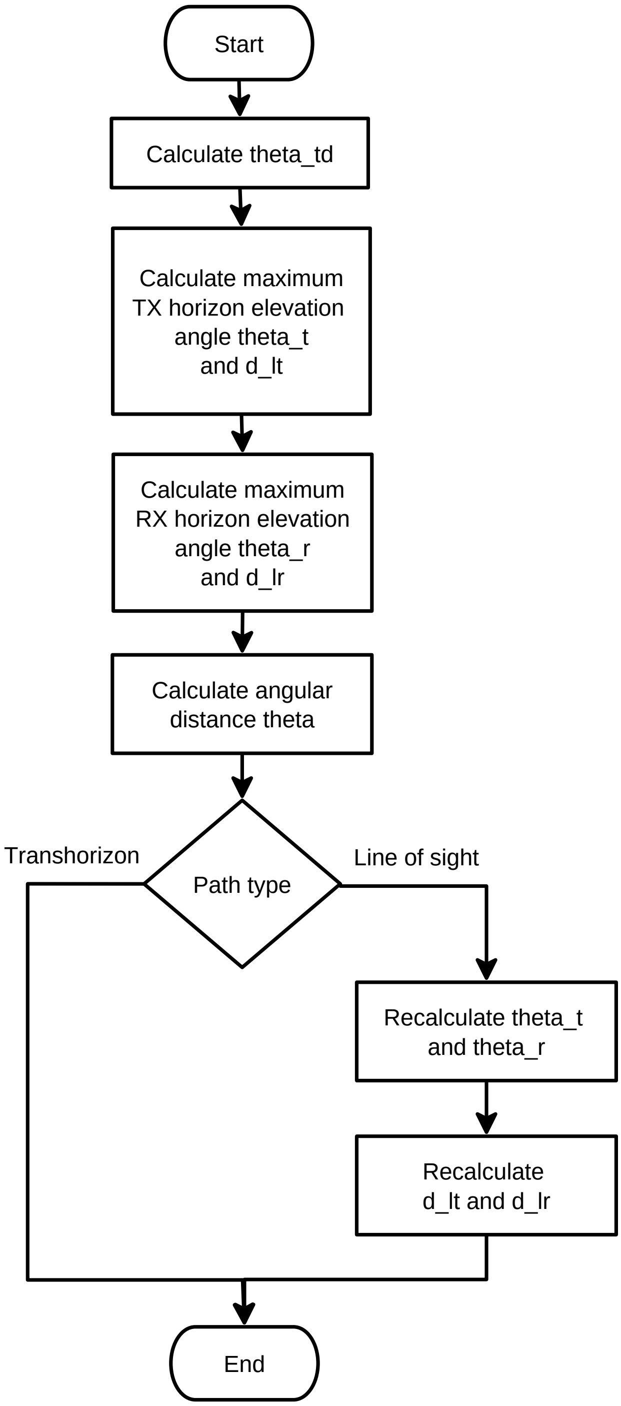
Calculate NFD and overlapping area

Program calculates overlapping area for co-channel situation, and then calculates overlapping area with the frequency difference TX – RX. From these parameters NFD is calculated.

Calculate MD

Calculation of mask discrimination is performed.

2.1.2.2 Path profile analysis


Start
Calculate theta_td
Calculate maximum TX horizon elevation angle theta_t and d_lt
Calculate maximum RX horizon elevation angle theta_r and d_lr
Calculate angular distance theta
Transhorizon
Path type
Line of sight
Recalculate theta_t and theta_r
Recalculate d_lt and d_lr
End

Calculate theta_td

Parameter theta_td is calculated according to the formulae 13 of Annex 10 to the HCM-Agreement. This parameter is used for the path classification.

Calculate maximum TX horizon elevation angle theta_t and d_lt

Theta_t (Θ_t) is calculated according to the formulae 14 of Annex 10 to the HCM-Agreement. D_lt (d_{lt}) is the distance from the transmitter to its horizon.

Calculate maximum RX horizon elevation angle theta_r and d_lr

Theta_r (Θ_r) is calculated according to the formulae 16 of Annex 10 to the HCM-Agreement. D_lr (d_{lr}) is the distance from the receiver to its horizon.

Calculate angular distance theta

Angular distance Θ is calculated according to the formulae 18 of Annex 10 to the HCM-Agreement.

Path type

Path is defined by the condition 10 of Annex 10 to the HCM-Agreement. Path can be either line of sight or transhorizon.

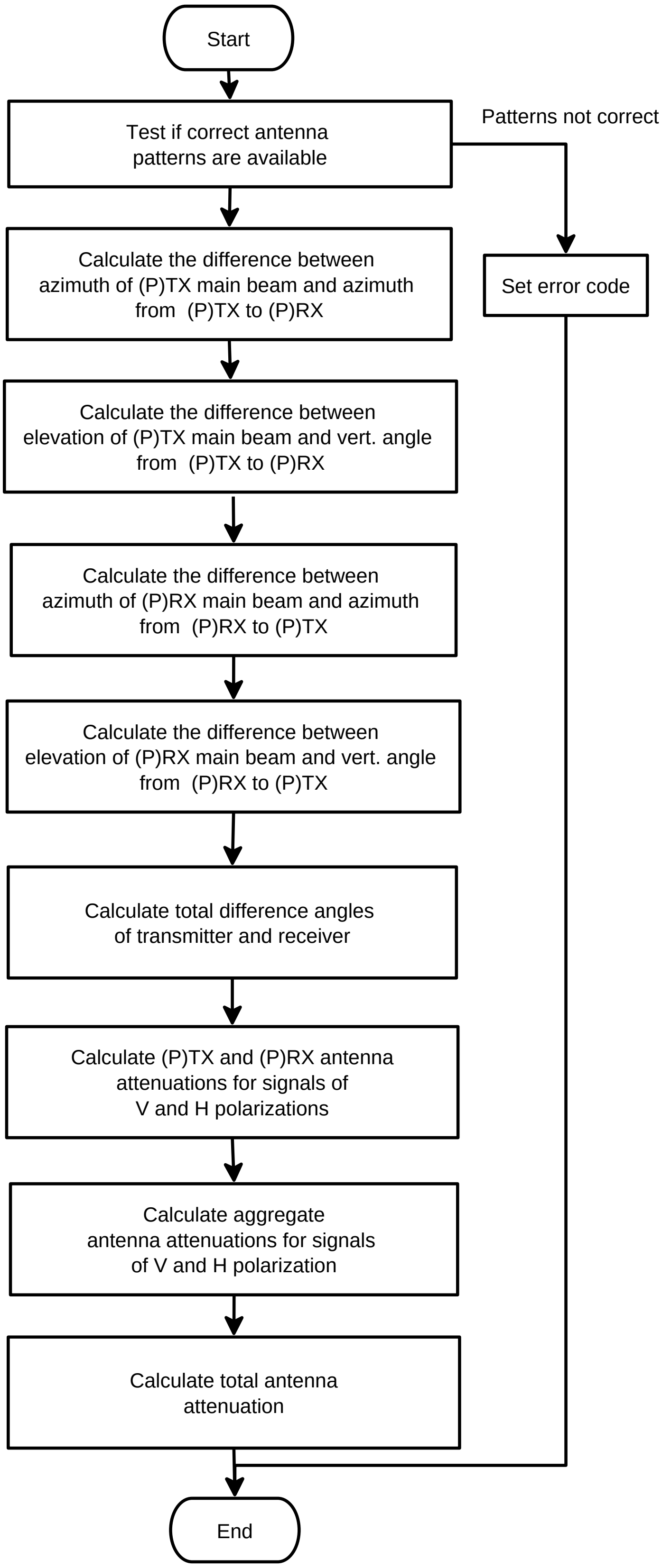
Recalculate theta_t and theta_r

In case path type is line of sight Θ_r and Θ_t must be set according to TABLE 3 of Annex 10 to the HCM-Agreement.

Recalculate d_lt and d_lr

Line of sight case also influences the way d_{lt} and d_{lr} are defined. In this case the profile point has to be found which is identified as the principal edge in the diffraction method for 50% time. Distances d_{lt} and d_{lr} will be the distances to that point from the transmitter and receiver respectively.

2.1.2.3 Total antenna attenuation


Start
Test if correct antenna patterns are available
Patterns not correct
Set error code
Calculate the difference between azimuth of (P)TX main beam and azimuth from (P)TX to (P)RX
Calculate the difference between elevation of (P)TX main beam and vert. angle from (P)TX to (P)RX
Calculate the difference between azimuth of (P)RX main beam and azimuth from (P)RX to (P)TX
Calculate the difference between elevation of (P)RX main beam and vert. angle from (P)RX to (P)TX
Calculate total difference angles of transmitter and receiver
Calculate (P)TX and (P)RX antenna attenuations for signals of V and H polarizations
Calculate aggregate antenna attenuations for signals of V and H polarization
Calculate total antenna attenuation
End

For total antenna attenuation a function calcA_ant is used.

Test if correct antenna patterns are available

TX and RX must have correct co-polar and cross-polar antenna patterns. Co-polar antenna pattern must be CP, VV (if polarization is V), or HH (if polarization is H). Cross-polar antenna pattern must be XP, VH (if polarization is V), or HV (if polarization is H).

Calculate horizontal and vertical angle differences

After testing antenna patterns it is required to calculate horizontal and vertical difference angles for (P)TX and (P)RX. The differences are calculated between main beam of (P)TX, (P)RX, and the direction to the interferer or interfered-with station.

Calculate (P)TX and (P)RX antenna attenuations for signals of V and H polarizations

This calculates parameters aTx-x and aRx-x (page 5 of Annex 9 to the HCM-Agreement). In the program the parameters are represented as a_Tc, a_Tx, a_Rc, a_Rx.

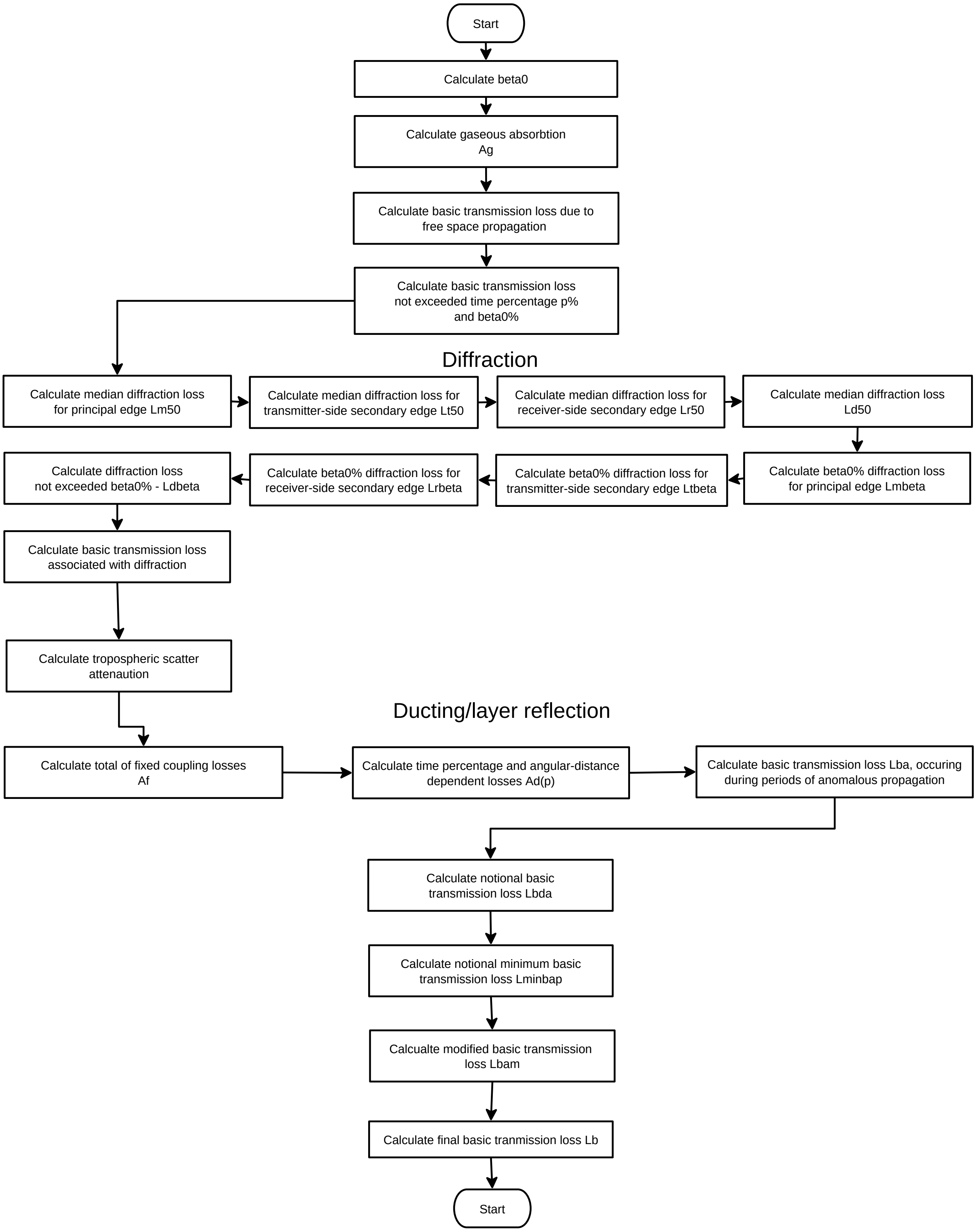
Calculate aggregate antenna attenuations for signals of V and H polarization

This combines (P)TX and (P)RX antenna attenuations for V and H polarizations according to TABLE 1 of the Annex 9 to the HCM-Agreement. Result is aantH and aantV (represented by the parameters “co” and “xo” in the program).

Calculate total antenna attenuation

Total antenna attenuation aant is calculated according to formulae on the page 5 of Annex 9 to the HCM-Agreement.

2.1.2.4 Propagation loss


Start
Calculate beta0
Calculate gaseous absorbtion Ag
Calculate basic transmission loss due to free space propagation
Calculate basic transmission loss not exceeded time percentage p% and beta0%
Diffraction
Calculate median diffraction loss for principal edge Lm50
Calculate median diffraction loss for transmitter-side secondary edge Lt50
Calculate median diffraction loss for receiver-side secondary edge Lr50
Calculate median diffraction loss Ld50
Calculate beta0% diffraction loss for principal edge Lmbeta
Calculate beta0% diffraction loss for transmitter-side secondary edge Ltbeta
Calculate beta0% diffraction loss for receiver-side secondary edge Lrbeta
Calculate diffraction loss not exceeded beta0% - Ldbeta
Calculate basic transmission loss associated with diffraction
Calculate tropospheric scatter attenaution
Ducting/layer reflection
Calculate total of fixed coupling losses Af
Calculate time percentage and angular-distance dependent losses Ad(p)
Calculate basic transmission loss Lba, occuring during periods of anomalous propagation
Calculate notional basic transmission loss Lbda
Calculate notional minimum basic transmission loss Lminbap
Calcualte modified basic transmission loss Lbam
Calculate final basic tranmission loss Lb
Start

Calculation of propagation loss is described in Annex 10 to the HCM-Agreement. Therefore all references to the formulas mentioned in this paragraph mean formulas as they are described in the Annex 10 to the HCM-Agreement.

Calculate beta0

This calculates time percentage for which refractive index lapse-rates exceeding 100 N-units/km can be expected in the first 100 m of the lower atmosphere (formulae 1).

Calculate gaseous absorption

This calculates gaseous absorption according to formulae 21.

Calculate basic transmission loss due to free space propagation

This calculates basic transmission loss due to free-space propagation and attenuation by atmospheric gases L_{bfsg} according to formulae 20.

Calculate basic transmission loss not exceeded time percentage p% and beta0%

This calculates basic transmission loss not exceeded for time percentage, p% ,and beta0%, due to line-of-sight propagation (formulas 27, 28).

Diffraction

After line of sight calculations are done subroutine moves on for calculation of diffraction loss (§ 6.2). First, there are a number of operations performed to get median diffraction loss (§ 6.2.1). After that the same operations are performed for obtaining diffraction loss not exceeded beta0% of time (§ 6.2.2).

Calculate median diffraction loss for principal edge Lm50.

It performs calculations of the median knife-edge diffraction loss for the main edge, L_{m50} according to the formulae 33.

Calculate median diffraction loss for transmitter-side secondary edge Lt50.

Calculate the median knife-edge diffraction loss for the transmitter-side secondary edge, L_{t50} according to the formulae 37.

Calculate median diffraction loss for receiver-side secondary edge Lr50.

Calculate the median knife-edge diffraction loss for the receiver-side secondary edge, L_{r50} (formulae 41).

Calculate median diffraction loss Ld50

The calculations are performed according to formulae 42 which finalize calculation series for obtaining median diffraction loss.

Calculate beta0% diffraction loss for principal edge Lmβ.

It performs calculations of the knife-edge diffraction loss for the main edge, $L_{m\beta}$, according to the formulae 45.

Calculate beta0% diffraction loss for transmitter-side secondary edge Ltβ.

It calculates the knife-edge diffraction loss for the transmitter-side secondary edge, $L_{t\beta}$, according to the formulae 48.

Calculate beta0% diffraction loss for receiver-side secondary edge Lrβ.

It calculates the knife-edge diffraction loss for the receiver-side secondary edge, $L_{r\beta}$, (formulae 51).

Calculate diffraction loss not exceeded beta0% – Ldβ

The calculations are performed according to formulae 52 which finalize calculation series for obtaining diffraction loss not exceeded for β_0% of the time, $L_{d\beta}$.

Calculate basic transmission loss associated with diffraction

It calculates the diffraction loss, Ldp, not exceeded for p% time (formulae 56), the median basic transmission loss associated with diffraction, L_{bd50} (formulae 57), and finally, the basic transmission loss associated with diffraction not exceeded for p% (formulae 58). This ends diffraction calculations.

Calculate tropospheric scatter attenuation

This calculates the basic transmission loss due to troposcatter, L_{bs} (p) (dB) not exceeded for any time percentage, p%, according to formulae 68.

Ducting/Layer reflection

Calculations of loss due to anomalous propagation is divided into three main steps and is calculated according to § 6.4.

Calculate total of fixed coupling losses

Calculations of total of fixed coupling losses (except for local clutter losses) between the antennas and the anomalous propagation structure within the atmosphere are performed according to formulae 72.

Calculate time percentage and angular-distance dependent losses Ad(p)

Time percentage and angular-distance dependent losses within the anomalous propagation mechanism are calculated using the formulae 77.

Calculate basic transmission loss Lba, occurring during periods of anomalous propagation

Calculation of the basic transmission loss, L_{ba} (dB) occurring during periods of anomalous propagation (ducting and layer reflection) is based on the formulae 71. This ends calculations of ducting/layer reflection.

Calculate notional basic transmission loss Lbda

This calculates the notional basic transmission loss, L_{bda} (dB), associated with diffraction and line-of-sight or ducting/layer-reflection enhancements (formulae 92).

Calculate notional minimum basic transmission loss Lminbap

It calculates the notional minimum basic transmission loss, L_{minbap} (dB), associated with line-of-sight and transhorizon signal enhancements (formulae 91)

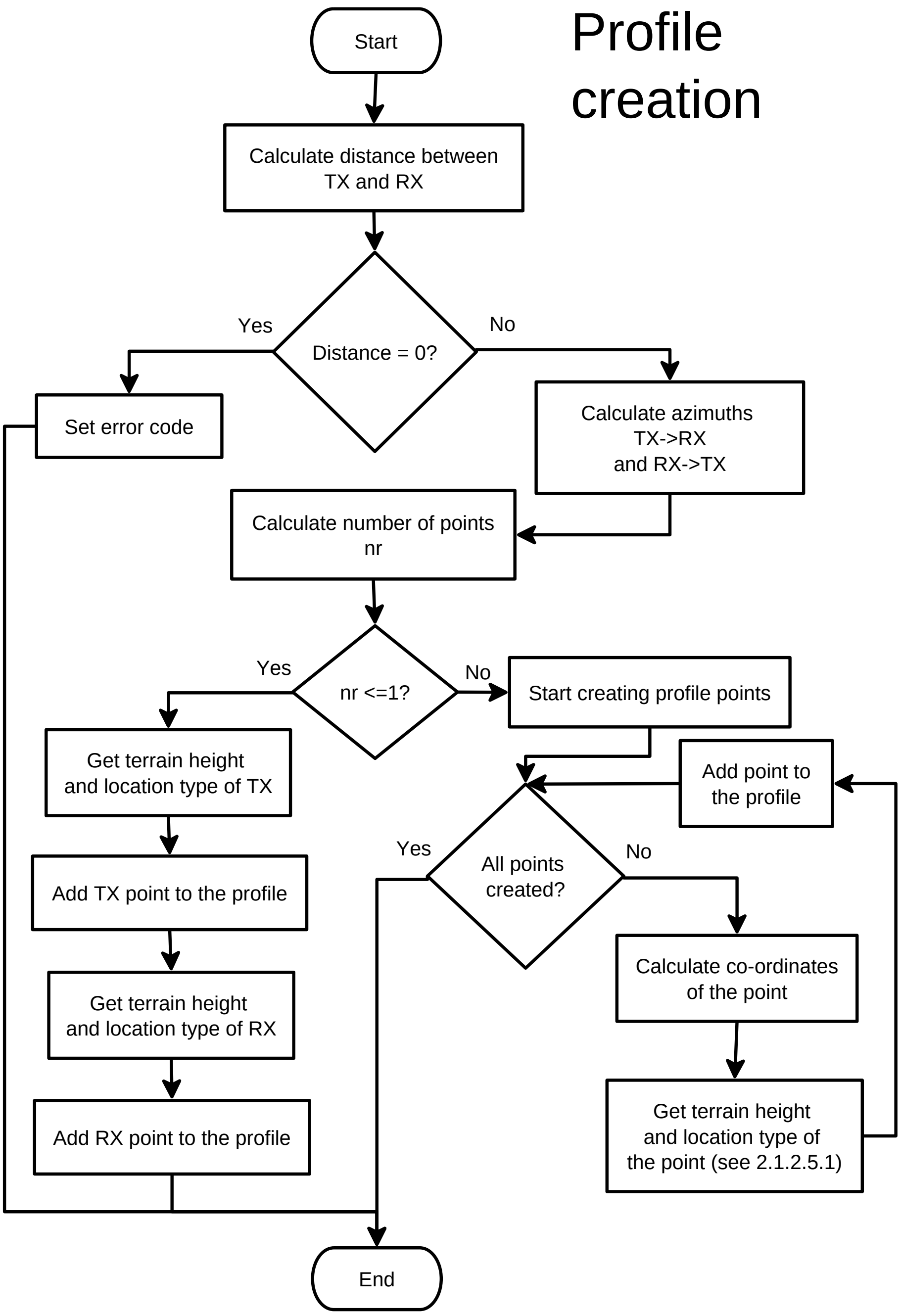
Calculate modified basic transmission loss Lbam

This calculates the modified basic transmission loss, L_{bam} (dB), which takes diffraction and line-of-sight or ducting/layer-reflection enhancements into account (formulae 93).

Calculate final basic transmission loss Lb

Propagation calculations end getting the final basic transmission loss not exceed for p% time, L_b (dB), according to formulae 94.

2.1.2.5 Terrain profile creation



Profile creation
Start
Calculate distance between TX and RX
Distance = 0?
Yes
No
Set error code
Calculate azimuths TX->RX and RX->TX
Calculate number of points nr
nr <=1?
Yes
No
Start creating profile points
Get terrain height and location type of TX
Add TX point to the profile
Get terrain height and location type of RX
Add RX point to the profile
All points created?
Yes
No
Add point to the profile
Calculate co-ordinates of the point
Get terrain height and location type of the point (see 2.1.2.5.1)
End

Calculate distance between TX and RX

Calculates distance between the first (TX) and the last (RX) points of the profile.

Distance = 0?

If distance between TX and RX equals to 0 it means that TX and RX located on the same mast. Currently HCM method does not support calculations when TX and RX are located on the same site because usually such scenario does not occur in the coordination process.

Set error code

If TX and RX located on the same site, appropriate error code is generated.

Calculate azimuth TX->RX and RX->TX

Azimuth form transmitter to receiver and vice versa is calculated.

Calculate number of points

Number of profile points is calculated by rounding division of distance by step which is currently set to 100 m:

round(distance / 100 m)

nr<=1?

In case of short distance (less than 150 m) profile will be created containing two points – TX location and RX location, otherwise profile will be created with the evenly spread points with the step of about 100 m.

Start creating profile points

This starts a cycle where all profile points are created.

All points created?

When all points are created process is stopped.

Calculate co-ordinates of the point

By knowing co-ordinates of the first and the last points of the profile, program calculates co-ordinates of intermediate point.

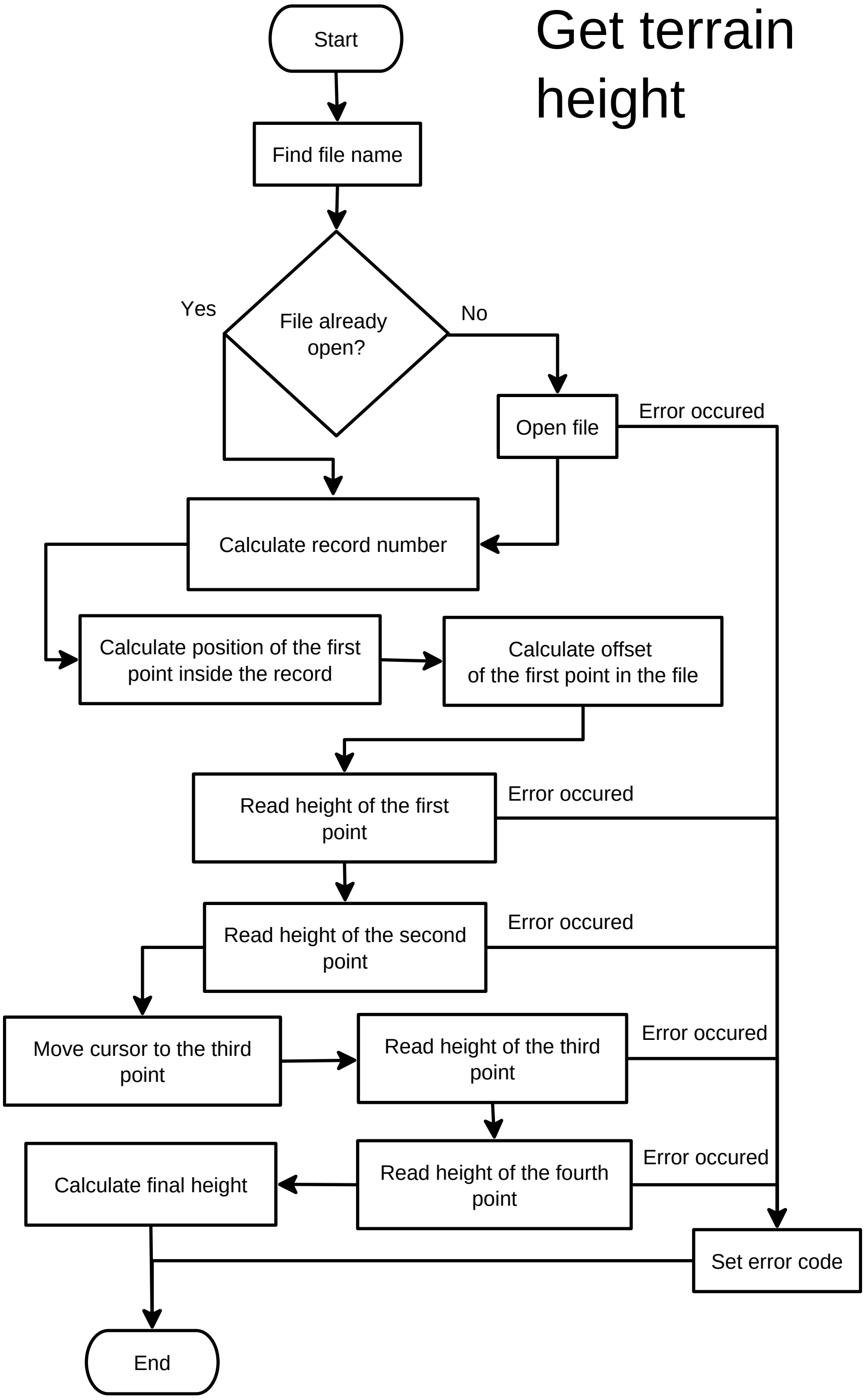
Get terrain height and location type of the point

Since the co-ordinates of the profile point has been calculated, the program calculates height above sea level and type of the point. See 2.1.2.5.1 Get terrain height and location type of the point for more details.

Add point to the profile

The point with calculated height and type is added to the profile.

2.1.2.5.1 Get terrain height and location type of the point


Get terrain height
Start
Find file name
File already open?
Yes
No
Open file
Error occured
Calculate record number
Calculate position of the first point inside the record
Calculate offset of the first point in the file
Read height of the first point
Error occured
Read height of the second point
Error occured
Move cursor to the third point
Read height of the third point
Error occured
Read height of the fourth point
Error occured
Calculate final height
Set error code
End

Since procedure for getting location type from morphological data files is exactly the same as the procedure for getting terrain height therefore only procedure for getting terrain height will be explained in this document.

Find file name

Terrain data files have strict file name system which is defined in 4. STORAGE FORMAT OF HEIGHT DATA. By having longitude and latitude the terrain file name is constructed.

File already open?

Program checks whether required file name is already open. File is opened when it is accessed for the first time. File is closed when HCM FS DLL is unloaded by the surrounding program.

Open file

If file is not opened program opens it.

Set error code

If file cannot be opened (is missing or not enough access rights) or reading problem occurs, appropriate error code is set.

Calculate record number

Terrain file is divided into records. In order to get height data, appropriate record has to be found first.

Calculate position of the first point inside the record

In order to get height data of the required point, four closest terrain points have to be found. In this function position of the first point inside the record is calculated.

Calculate offset of the first point in the file

Since number of the record and position of the point inside the record is already calculated, therefore it is possible to calculate point position in the file.

Read height of the first point

Knowing offset of the first point to read, program reads it. In case of error it sets appropriate error code.

Read height of the second point

After reading first point, cursor is automatically positioned at the second point. Program reads it.

Move cursor to the third point

Third point is not following the second one. It is located further in the record. Program calculates it and moves cursor to the position of the third point.

Read height of the third point

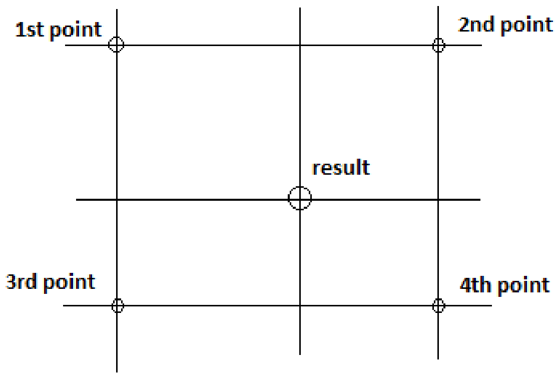
Program reads height of the third point. In case of error it sets appropriate error code.

Read height of the fourth point

Program reads height of the fourth point. In case of error it sets appropriate error code.

Calculate final height

Height of the point is calculated using bilinear interpolation.



2.1.3 Error codes

The HCM_FS interference calculation subroutine generates the following error codes:

0	No error
36	Error opening topo data file (no data)
220	Error reading terrain record
400	Height is missing (-9999)
1000	Tx record is not a Tx
1001	Rx record is not a Rx
1002	Tx frequency (1A) not present
1003	Tx frequency unit (1A1) not present
1004	Tx co-ordinates (4C) not present
1005	Tx height of site above sea level (4Z) not present
1006	Transmitter spectrum mask (7G) (frequency) is not present
1007	Transmitter spectrum mask (7G) (attenuation) is not present
1008	Tx power (8A) is not present
1010	Tx azimuth (9A) is not present
1011	Tx elevation (9B) is not present
1012	Tx polarization (9D) is not present
1014	Tx antenna height above ground (9Y) is not present
1015	Tx antenna gain (part of 9X) is not present
1016	Default Tx antenna radiation pattern (9X) is not present
1020	Rx frequency (1A) not present
1021	Rx frequency unit (1A1) not present
1022	Rx co-ordinates (4C) not present
1023	Rx height of site above sea level (4Z) not present
1024	Error in Tx channel spacing (7G3)
1026	Rx azimuth (9A) is not present
1027	Rx elevation (9B) is not present
1028	Rx polarization (9D) is not present
1029	Rx noise power level FKTB (9H) is not present
1031	Rx antenna height above ground (9Y) is not present
1032	Rx antenna gain (part of 9X) is not present

1033	Default Rx antenna radiation pattern (9X) is not present
1037	Error in Tx frequency (1A)
1038	Error in Tx frequency unit (1A1)
1039	Error in Tx frequency range (only 1 - 43.5 GHz are permissible)
1040	Error in Rx frequency (1A)
1041	Error in Rx frequency unit (1A1)
1042	Error in Rx frequency range (only 1 - 43.5 GHz are permissible)
1043	Error in Tx co-ordinates (4C)
1044	Error in Rx co-ordinates (4C)
1045	Error in Tx site height (4Z)
1046	Error in Rx site height (4Z)
1047	Error in Tx spectrum mask data (7G)
1048	Error in Rx selectivity mask data (7G)
1049	Error in Tx power (8A)
1050	Error in Tx ATPC (8B3)
1051	Error in Tx azimuth (9A)
1052	Error in Rx azimuth (9A)
1053	Error in Tx elevation (9B)
1054	Error in Rx elevation (9B)
1055	Error in (Rx) FkTB (9H)
1056	Error in Tx line losses (9L)
1057	Error in Rx line losses (9L)
1058	Error in Tx antenna height (9Y)
1059	Error in Rx antenna height (9Y)
1060	Error in Tx antenna gain (in 9X)
1061	Error in Rx antenna gain (in 9X)
1062	Tx position = Rx position; calculations not possible
1070	Receiver selectivity mask (7G) (frequency) is not present
1071	Receiver selectivity mask (7G) (attenuation) is not present
1077	PTx record is not a PTx
1079	PTx co-ordinates (4C) not present
1080	PTx height of site above sea level (4Z) not present
1081	PTx azimuth (9A) is not present
1082	PTx elevation (9B) is not present
1083	PTx polarization (9D) is not present
1084	PTx antenna height above ground (9Y) is not present
1085	PTx antenna gain (part of 9X) is not present
1086	Default PTx antenna radiation pattern (9X) is not present
1090	PRx record is not a PRx
1091	PRx co-ordinates (4C) not present
1092	PRx height of site above sea level (4Z) not present
1093	PRx azimuth (9A) is not present
1094	PRx elevation (9B) is not present
1095	PRx polarization (9D) is not present
1096	PRx antenna height above ground (9Y) is not present

1097	PRx antenna gain (part of 9X) is not present
1098	Default PRx antenna radiation pattern (9X) is not present
1102	Error in PTx co-ordinates (4C)
1103	Error in PRx co-ordinates (4C)
1104	Error in PTx site height (4Z)
1105	Error in PRx site height (4Z)
1106	Error in PTx azimuth (9A)
1107	Error in PRx azimuth (9A)
1108	Error in PTx elevation (9B)
1109	Error in PRx elevation (9B)
1110	Error in PTx line losses (9L)
1111	Error in PRx line losses (9L)
1112	Error in PTx antenna height (9Y)
1113	Error in PRx antenna height (9Y)
1114	Error in PTx antenna gain (in 9X)
1115	Error in PRx antenna gain (in 9X)
1116	Tx position = PRx position; calculations not possible
1118	PTx position = Rx position; calculations not possible
1203	Invalid Tx copolar radiation pattern (part of 9X)
1204	Invalid number of Tx copolar radiation pattern data (part of 9X)
1205	Invalid or missing Tx copolar antenna data (part of 9X)
1206	Invalid or missing Tx crosspolar radiation pattern (part of 9X)
1207	Invalid number of Tx crosspolar radiation pattern data (part of 9X)
1208	Invalid or missing Tx crosspolar antenna data (part of 9X)
1209	Invalid Rx copolar radiation pattern (part of 9X)
1210	Invalid number of Rx copolar radiation pattern data (part of 9X)
1211	Invalid or missing Rx copolar antenna data (part of 9X)
1212	Invalid or missing Rx crosspolar radiation pattern (part of 9X)
1213	Invalid number of Rx crosspolar radiation pattern data (part of 9X)
1214	Invalid or missing Rx crosspolar antenna data (part of 9X)
1215	Invalid PTx polarization (9D)
1216	Invalid PRx polarization (9D)
1217	Invalid Tx polarization (9D)
1218	Invalid Rx polarization (9D)
1219	Invalid PTx copolar radiation pattern (part of 9X)
1220	Invalid PRx copolar radiation pattern (part of 9X)
1221	Invalid number of PTx copolar radiation pattern data (part of 9X)
1222	Invalid number of PRx copolar radiation pattern data (part of 9X)
1223	Invalid or missing PTx copolar antenna data (part of 9X)
1224	Invalid or missing PRx copolar antenna data (part of 9X)
1225	Invalid or missing PTx crosspolar radiation pattern (part of 9X)
1226	Invalid or missing PRx crosspolar radiation pattern (part of 9X)
1227	Invalid number of PTx crosspolar radiation pattern data (part of 9X)
1228	Invalid number of PRx crosspolar radiation pattern data (part of 9X)
1229	Invalid or missing PTx crosspolar antenna data (part of 9X)

1230	Invalid or missing PRx crosspolar antenna data (part of 9X)
1233	Tx spectrum mask has less than 2 pairs of frequency and attenuation
1234	Rx selectivity mask has less than 2 pairs of frequency and attenuatio
1235	Last attenuation of Tx spectrum mask < 40 dB
1236	Last attenuation of Rx selectivity mask < 40 dB
1237	Error opening the result file
1238	Error writing data to the result file
1241	Invalid name of transmitter equipment class (7G1)
1242	Invalid name of receiver equipment class (7G1)
1243	No default transmitter mask data (7G) available
1244	No default receiver mask data (7G) available
1245	Could not find parameter file hcmrc
1246	Could not open registry key HKEY_LOCAL_MASHINE\Software\HCM
1247	Could not read topo path value from registry
1248	Error in Rx channel spacing (7G3)

2.2 HCM-FS TRIGGER FOR CO-ORDINATION

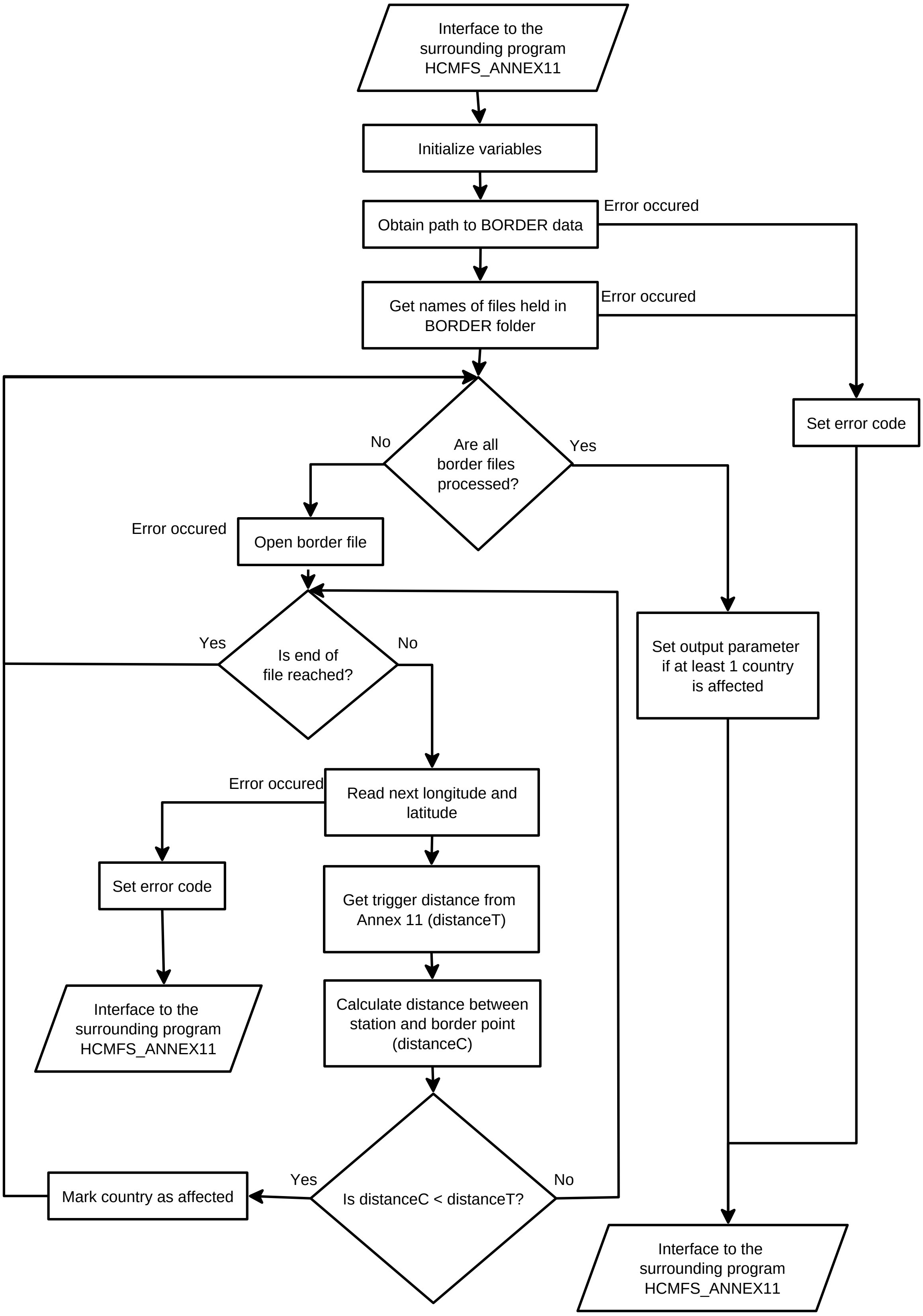
This feature of HCM-FS is supposed to help administrations on decision whether a station should be sent for coordination. Decision is made on a distance to the border. All distances depending on the frequency band are defined in Annex 11 to the HCM-Agreement.

Calculation library has three different interfaces which can be accessed for calculation of the trigger:

- HCMFS_ANNEX11,
- HCMFS_ANNEX11_1,
- HCMFS_ANNEX11_2.

Interface HCMFS_ANNEX11 is the main one. Other interfaces have different input parameters and are provided for conveniance only.

2.2.1 HCMFS_ANNEX11


Interface to the surrounding program HCMFS_ANNEX11
Initialize variables
Obtain path to BORDER data
Error occured
Get names of files held in BORDER folder
Error occured
Set error code
Are all border files processed?
No
Yes
Error occured
Open border file
Is end of file reached?
Yes
No
Set output parameter if at least 1 country is affected
Error occured
Read next longitude and latitude
Set error code
Get trigger distance from Annex 11 (distanceT)
Interface to the surrounding program HCMFS_ANNEX11
Calculate distance between station and border point (distanceC)
Is distanceC < distanceT?
Yes
No
Mark country as affected
Interface to the surrounding program HCMFS_ANNEX11

Interface to the surrounding program HCMFS_ANNEX11

```
HCMFS_ANNEX11(int &error, double longitude, double latitude,
              int h_asl, double frequency_GHz, char* outcome,
              const char* drive)
```

Output parameters:

outcome	List of countries to coordinate with or empty, if no coordination is required
error	Error code

Input parameters:

longitude	Station longitude
latitude	Station latitude
h_asl	Antenna height above sea level
frequency_GHz	Frequency of the station
drive	For Windows – drive letter of the drive containing the BORDER directory, or empty (see Requirements). For Linux this parameter is not used and can be left empty.

Requirements

Registry key	FOR WINDOWS ONLY. If drive is empty, program searches for border path in Windows registry. The following registry key should be available: HKEY_LOCAL_MASHINE\Software\HCM\border (SZ type). Mandatory. Contains path of border data.
Borderline data	Borderline data in HCM format. Mandatory. Data has to be placed into BORDER directory (if drive contains drive letter), or into the directory specified by registry (for Windows), or the parameter file (for Linux).
/etc/hcmfs or ~/.hcmrs	FOR LINUX ONLY. Parameter file. Mandatory for Linux. See HCMFS_V2 Requirements for details.

Initialize variables

In this step program initializes some variables, cleans up output parameter.

Obtain path to border data

For Windows

If drive letter is submitted to HCMFS_ANNEX11 interface (parameter drive) then path is set to:

drive:\BORDER

If drive letter is not submitted then program searches registry for the key

HKEY_LOCAL_MASHINE\Software\HCM\border,

and sets appropriate path.

If neither drive letter nor registry key is present program sets appropriate error code.

For Linux

Program does not look at the parameter *drive*. It searches for a file .hcmrc in the HOME folder of the current user. If the file does not exist it looks for the file /etc/hcmrc. If it is not present program sets an error. If the program finds the file it reads it and searches for the parameter BORD, then sets appropriate path accordingly.

An example of hcmrc file:

BORD= /home/Thomas/hcm/border_data

Get names of files held in BORDER folder
When path to border data is obtained program searches folder content for files and gets their names.

Are all border files processed?
When the subroutine get names of the files held in border folder it stars reading them one by one. When all files are processed subroutine ends its calculations.

Open border file
This opens border file for reading.

Is end of file reached?
If end of border file is not reached program moves on reading coordinates of the next border point. In case end of file is reached program starts reading next file.

Read next longitude and latitude
Program reads longitude and latitude of a border point from the opened border file. Format of the border file is explained in 6. STORAGE FORMAT OF BORDERLINE DATA.

Get trigger distance from Annex 11 (distanceT)
Depending on frequency and antenna height above sea level program determines trigger distance. All trigger distances are defined in Annex 11 to the HCM-Agreement.

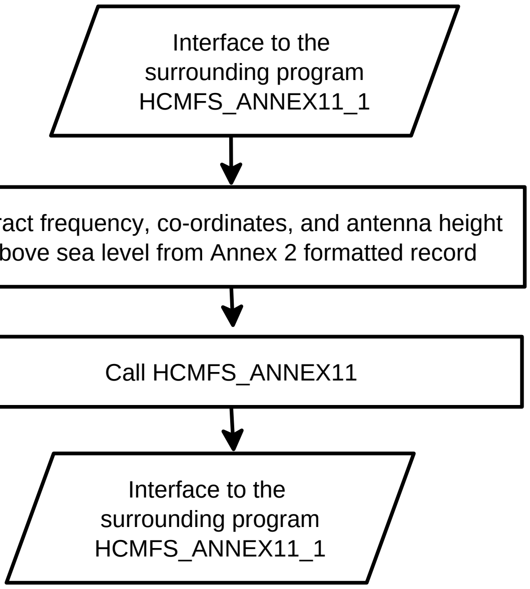
Calculate distance between station and border point (distanceC)
This calculates distance between station and current border point. It uses function getDistance of the class TTerrain.

Is distanceC < distanceT?
If calculated distance between station and current border point is less than trigger distance from Annex11 of the HCM-Agreement, station is considered as affected and should be coordinated.

Mark country as affected
If calculated distance between station and current border point is less than trigger distance from Annex11 of the HCM-Agreement, station is marked as affected and should be coordinated.

Set output parameter if at least 1 country is affected
If program finds out that station should be coordinate with at least 1 country, it writes appropriate county name(s) to the output parameter.

2.2.2 HCMFS_ANNEX11_1


Interface to the surrounding program HCMFS_ANNEX11_1
Extract frequency, co-ordinates, and antenna height above sea level from Annex 2 formatted record
Call HCMFS_ANNEX11
Interface to the surrounding program HCMFS_ANNEX11_1

Interface to the surrounding program HCMFS_ANNEX11_1

```
HCMFS_ANNEX11_1(int &I_Error, const char* I_Record1, long L1,
                  char* I_Record2, long L2, const char* I_Drive, long L3)
```

Output parameters:

I_Error	Error code
I_Record2	char[200]. Contains list of countries to coordinate with or empty, if no coordination is required.

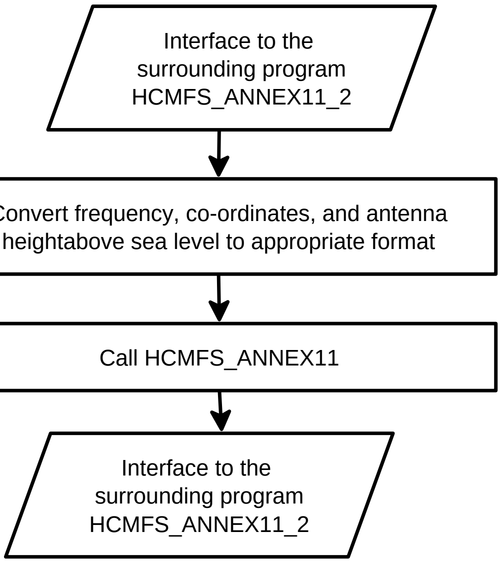
Input parameters:

L2	Length of I_Record2 (200).
I_Record1	Data record according to ANNEX 2B.
L1	Length of I_Record1. Required for compatibility with old dll.
I_Drive	Drive letter of the drive containing the BORDER directory, or empty (see Requirements). For Linux this parameter is not used therefore can be left empty.
L3	Length of I_Drive. Required for compatibility with old dll.

Requirements

For requirements see 2.2.1 HCMFS_ANNEX11.

2.2.3 HCMFS_ANNEX11_2


Interface to the surrounding program HCMFS_ANNEX11_2
Convert frequency, co-ordinates, and antenna heightabove sea level to appropriate format
Call HCMFS_ANNEX11
Interface to the surrounding program HCMFS_ANNEX11_2

Interface to the surrounding program HCMFS_ANNEX11_2

```
HCMFS_ANNEX11_2(int &I_Error, const char* I_COO, long L1,
                const char* I_FRE, long L2, const char* I_C, long L3,
                const char* I_AH, long L4, const char* I_SH, long L5,
                char* I_Record1, long L6,
                const char* I_Drive, long L7)
```

Output parameters:

I_Error	Error code
I_Record1	char[200]. Contains list of countries to coordinate with or empty, if no coordination is required.

Input parameters:

I_COO	Co-ordinates of the station (4C, ANNEX 2B)
L1	Length of I_COO
I_FRE	Frequency of the station (1A ANNEX 2B). En example of the format: “01600000.00K”, “7800M”
L2	Length of I_FRE
I_C	Country (4B ANNEX 2B)
L3	Length of I_C
I_AH	Antenna height (9Y ANNEX 2B)
L4	Length of I_AH
I_SH	Site height (4Z ANNEX 2B)
L5	Length of I_SH
L6	Length of I_Record1 (200)
I_Drive	Drive letter of the drive containing the BORDER directory, or empty (see Requirements). For Linux this parameter is not used therefore can be left empty.
L7	Length of I_Drive

Requirements

For requirements see 2.2.1 HCMFS_ANNEX11.

3. HCM-FS CALCULATION PROGRAM CALCFISH

CalcFiSH is created to help Administrations perform interference calculations according to HCM. In addition to that main purpose it allows creating, editing, checking, and comparing HCM-FS formatted files.

The program is cross-platform. Although the main platform for compilation is Windows, it may also be available for Linux. The program is created using C++ and QT library. It also uses Sqlite database for creation of calculation reports.

3.1 INTERFERENCE CALCULATIONS

CalcFiSH performs two types of interference calculations:

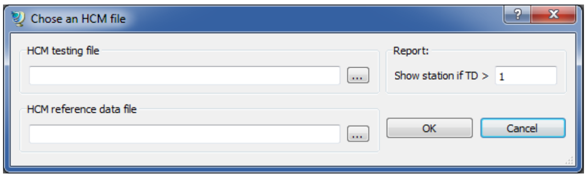
- List to list calculations. In this case user has to provide CalcFiSH with two files. One has to contain reference list of stations, another – the list of stations being tested.
- Single entry calculations. Program calculates interference just for a single case. User has to provide the program with the file containing either 2 or 4 records depending on whether passive repeater is present.

3.1.1 List to list calculations

List to list calculations perform analysis of one file entries against another.

Before performing calculations you need to set appropriate paths required by HCM-FS calculation library (HCMFS_DLL). For more information see 3.3.1 Paths.

To perform the calculations click the menu entry *Calculations/List – to List Calculations* or the button. *Choose HCM file* dialog box will appear.



Show station if TD > 1

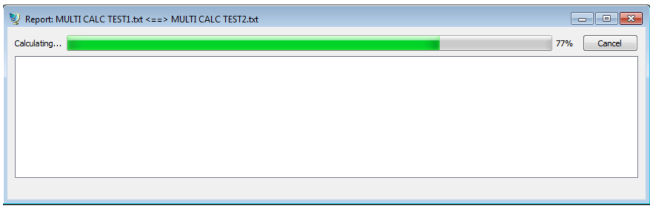
Under *HCM testing file* a file received from a neighbouring country or being sent to the neighbouring country should be choosen.

HCM reference data file represents already co-ordinated stations.

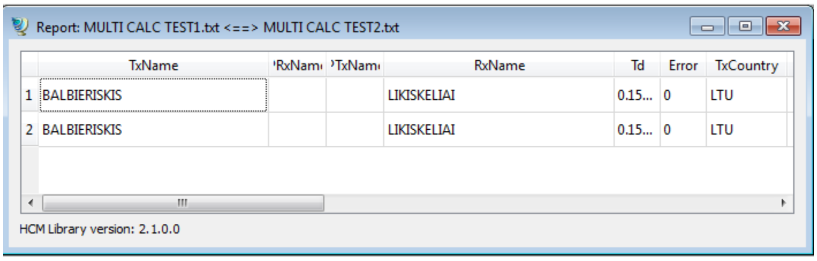
Value of *Show station if TD >* informs the program that all file entries which produced TD > than the value set have to be writen to the report file. When set to 0 it informs program that all calculation cases have to be written to the report file. Care should be taken when choosing the case of 0 dB because then calculations will take much more time.

Program also writes to the report cases when error occures.

After calculations are started report window will pop up showing calculation progress.



After calculations are made the program shows the report.



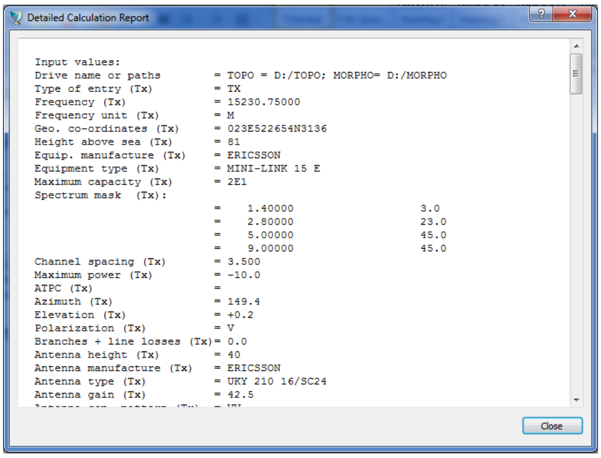
	TxName	RxNam	TxNam	RxName	Td	Error	TxCountry
1	BALBIERISKIS			LIKISKELIAI	0.15...	0	LTU
2	BALBIERISKIS			LIKISKELIAI	0.15...	0	LTU

HCM Library version: 2.1.0.0

Report can be saved and opened later. Program saves report to .cfrpt file. Since this is Sqlite data file, it can be opened using any database manager which supports Sqlite database.

At the bottom left corner HCM version of the library, which performed the calculations, is displayed.

By doubleclicking a report entry *Detailed Calculation Report* appears.



```
Input values:
Drive name or paths          = TOPO = D:/TOPO; MORPHO= D:/MORPHO
Type of entry (Tx)           = TX
Frequency (Tx)               = 15230.75000
Frequency unit (Tx)          = M
Geo. co-ordinates (Tx)       = 023E522654N3136
Height above sea (Tx)        = 81
Equip. manufacture (Tx)      = ERICSSON
Equipment type (Tx)          = MINI-LINK 15 E
Maximum capacity (Tx)        = 2E1
Spectrum mask  (Tx):
                             =    1.40000                3.0
                             =    2.80000                23.0
                             =    5.00000                45.0
                             =    9.00000                45.0
Channel spacing (Tx)         = 3.500
Maximum power (Tx)           = -10.0
ATPC (Tx)                    =
Azimuth (Tx)                 = 149.4
Elevation (Tx)               = +0.2
Polarization (Tx)            = V
Branches + line losses (Tx)= 0.0
Antenna height (Tx)          = 40
Antenna manufacture (Tx)     = ERICSSON
Antenna type (Tx)            = UKY 210 16/SC24
Antenna gain (Tx)            = 42.5
```

Please note that if the report is saved and opened next time, Detailed Calculation Report is not available.

3.1.2 Single entry calculations

The calculations are performed by clicking the menu entry *Calculations/Single Entry Calculations* or the button . The program behaves very similar to the List to list calculation case. After clicking the button *Choose HCM file* dialog box pops up. In this case only one file can be submitted.

The first record in this file always must be TX, the second – RX or PRX, the third – PTX (in case passive repeater is available), the forth – RX (in case passive repeater is available).

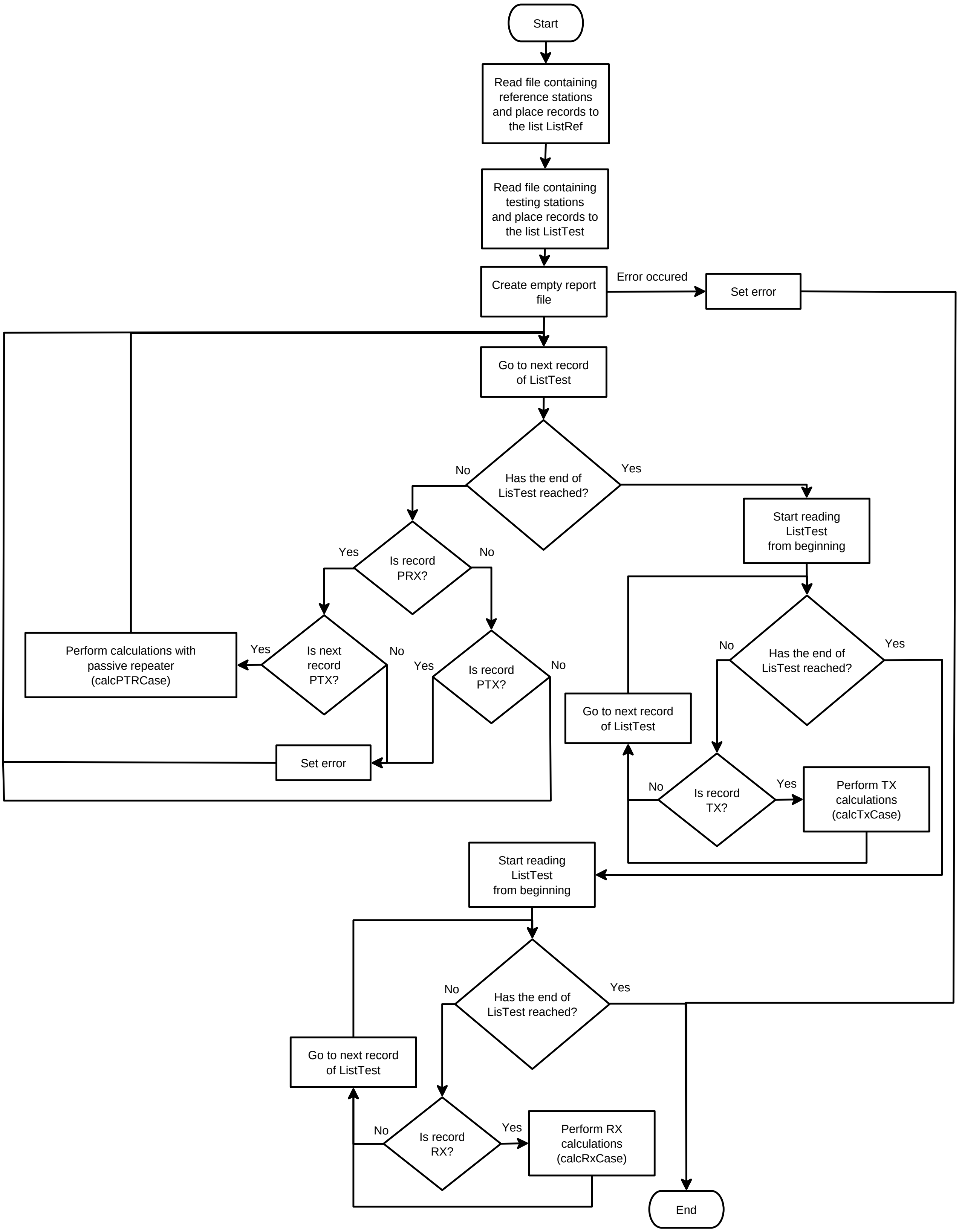
Calculations produce similar report as in 3.1.1 List to list calculations. By double-clicking it user gets detailed calculation report.

The report file can also be saved and opened later on.

3.1.3 Calculation diagrams

In this paragraph the calculation flowcharts are submitted.

3.1.3.1 List to list calculations



Start
Read file containing reference stations and place records to the list ListRef
Read file containing testing stations and place records to the list ListTest
Create empty report file
Error occured
Set error
Go to next record of ListTest
No
Has the end of LisTest reached?
Yes
Start reading ListTest from beginning
Yes
Is record PRX?
No
Yes
Is next record PTX?
No
Perform calculations with passive repeater (calcPTRCase)
Yes
Is record PTX?
No
Set error
No
Has the end of LisTest reached?
Yes
Go to next record of ListTest
No
Is record TX?
Yes
Perform TX calculations (calcTxCase)
Start reading ListTest from beginning
No
Has the end of LisTest reached?
Yes
Go to next record of ListTest
No
Is record RX?
Yes
Perform RX calculations (calcRxCase)
End

Calculations are divided into three symbolic parts. First, the program goes through the records of testing file (see below) and looks for passive repeater. In case it finds one it calls function calcPTRCase which tests all available combinations of different interfering paths, then moves on to the next record.

When finished, the program starts from the beginning of the ListTest and searches for transmitter. When it finds one, calls the function calcTxCase, which tests all available interfering scenarios, then moves on to the next record.

After transmitters are tested the programs again starts from the beginning of the ListTest and searches for receiver. When it finds one, calls calcRxCase and continues as is described in the transmitter case.

Below are given short descriptions of calculation process in case of passive repeater. Transmitter and receiver cases are very similar.

Read file containing reference stations and place records to the list ListRef

Programs reads *HCM reference data file* (see 3.1.1 List to list calculations) line by line and places its records to the list ListRef.

Read file containing testing stations and place records to the list ListTest

Programs reads *HCM testing file* (see 3.1.1 List to list calculations) line by line and places its records to the list ListTest.

Create empty report file

The program creates empty report file. In case it fails, the program ends with an error message.

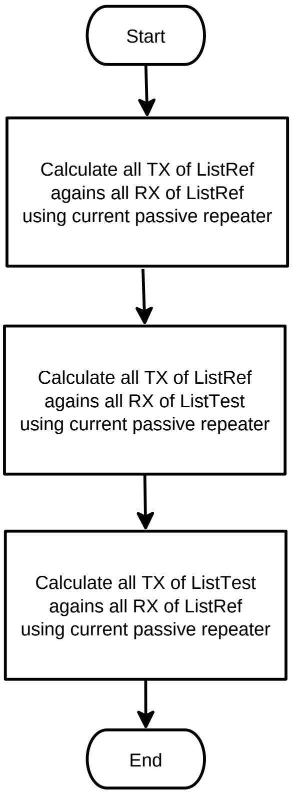
Go to next record of ListTest

After report is created the program starts analyzing records one by one, until the end of ListTest is reached.

Is record PRX?

If record is PRX, the program checks if the next record is PTX. If so, the program starts calculations using passive repeater. If the next record is not PTX, the program writes error to the report and moves on to the next record.

Perform passive calculations (calcPTRCase)


Start
Calculate all TX of ListRef agains all RX of ListRef using current passive repeater
Calculate all TX of ListRef agains all RX of ListTest using current passive repeater
Calculate all TX of ListTest agains all RX of ListRef using current passive repeater
End

When PRX and PTX records are found the program starts calculations using passive repeater (function calcPTRCase). Flowchart of calcPTRCase (see diagram above) shows main three parts of calculations.

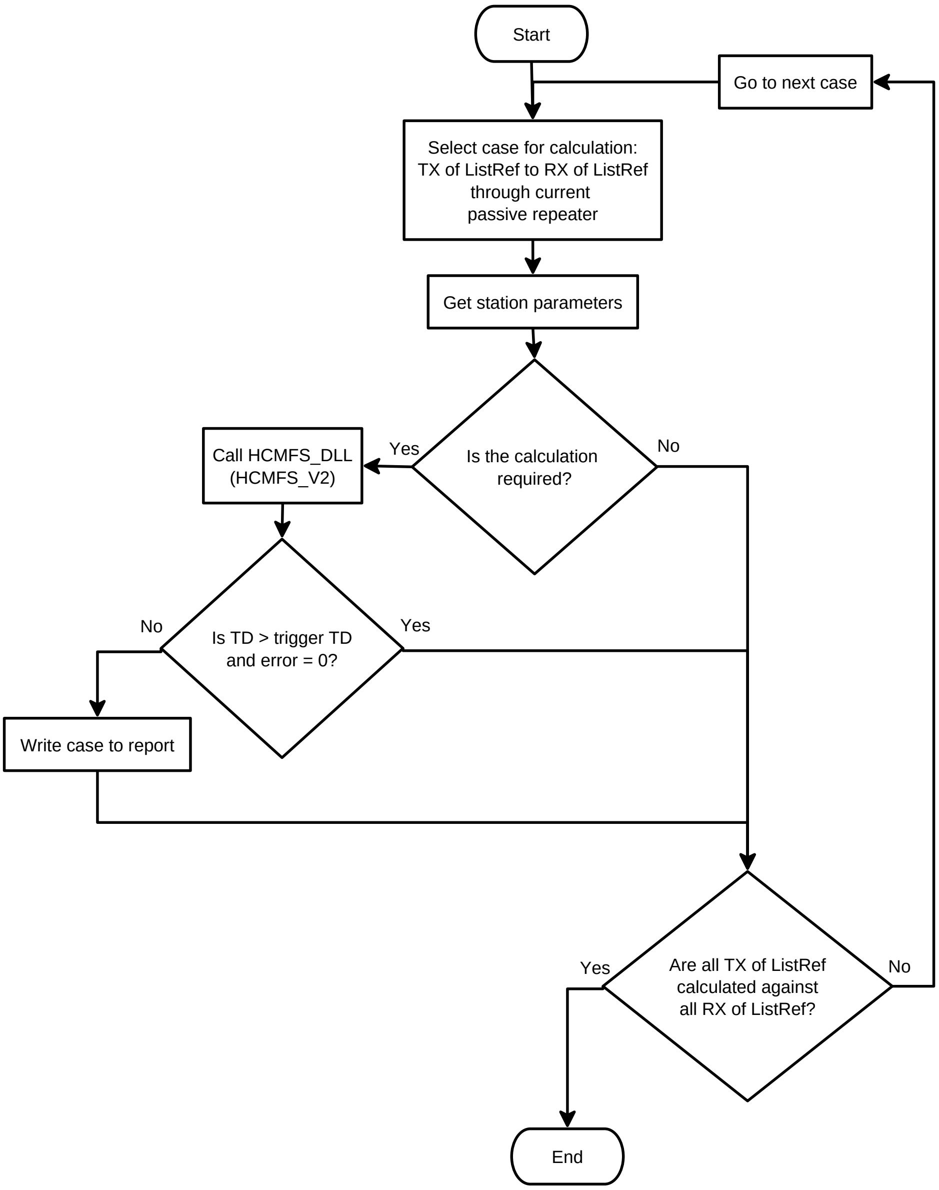
First, the program tests all TX of reference station file against all RX of the same file using currently found passive repeater.

Next, the program tests all TX of reference station file against all RX of testing station file using the same passive repeater.

Finally, all TX of testing station file are calculated against all RX of reference station file using current passive repeater.

Below flowchart of the first case is displayed. Other cases look very similar, therefore are not described in details.

Calculate all TX of ListRef against all RX of ListRef using current passive repeater


Start
Go to next case
Select case for calculation: TX of ListRef to RX of ListRef through current passive repeater
Get station parameters
Is the calculation required?
Yes
No
Call HCMFS_DLL (HCMFS_V2)
Is TD > trigger TD and error = 0?
No
Yes
Write case to report
Are all TX of ListRef calculated against all RX of ListRef?
Yes
No
End

Program calculates first found TX of ListRef against first found RX of ListRef using current passive repeater, and then it searches for the next pair of TX and RX until all combinations are tested.

Get station parameters

In order to meet certain criteria for calculations (see 3.3.4 Calculation) the program gets station co-ordinates, name, country and reference ID.

Is the calculation required?

Calculations are performed when distance between TX and RX is less than trigger distance defined in Options\Calculation. Distance to passive repeater is not taken into account, just distance between TX and RX. There is another condition that has to be fulfilled. Frequency difference between interferer TX and interfered-with RX has to be less than defined in Options\Calculations.

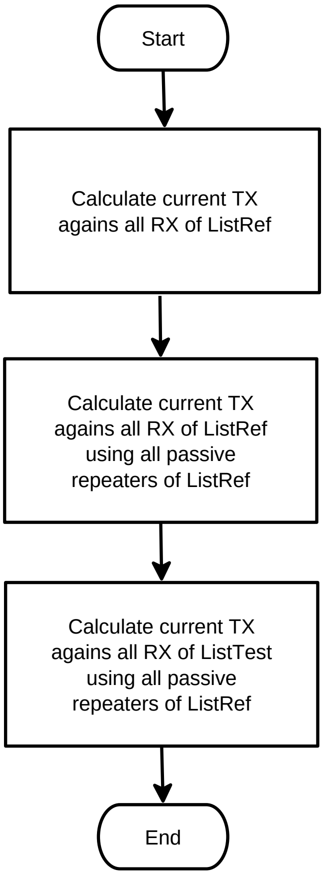
Call HCMFS_DLL (HCMFS_V2)

Calculations are performed in calculation library HCMFS_DLL therefore CalcFiSH calls HCMFS_V2 for calculations.

Is TD > trigger TD and error = 0?

CalcFiSH checks output of HCMFS_V2. If threshold degradation is greater than the trigger value (see 3.1.1 List to list calculations) or an error occurred, the program writes result to the report.

Perform TX calculations (calcTxCase)


Start
Calculate current TX agains all RX of ListRef
Calculate current TX agains all RX of ListRef using all passive repeaters of ListRef
Calculate current TX agains all RX of ListTest using all passive repeaters of ListRef
End

There are three main parts of calculations available for a particular transmitter of the testing station file.

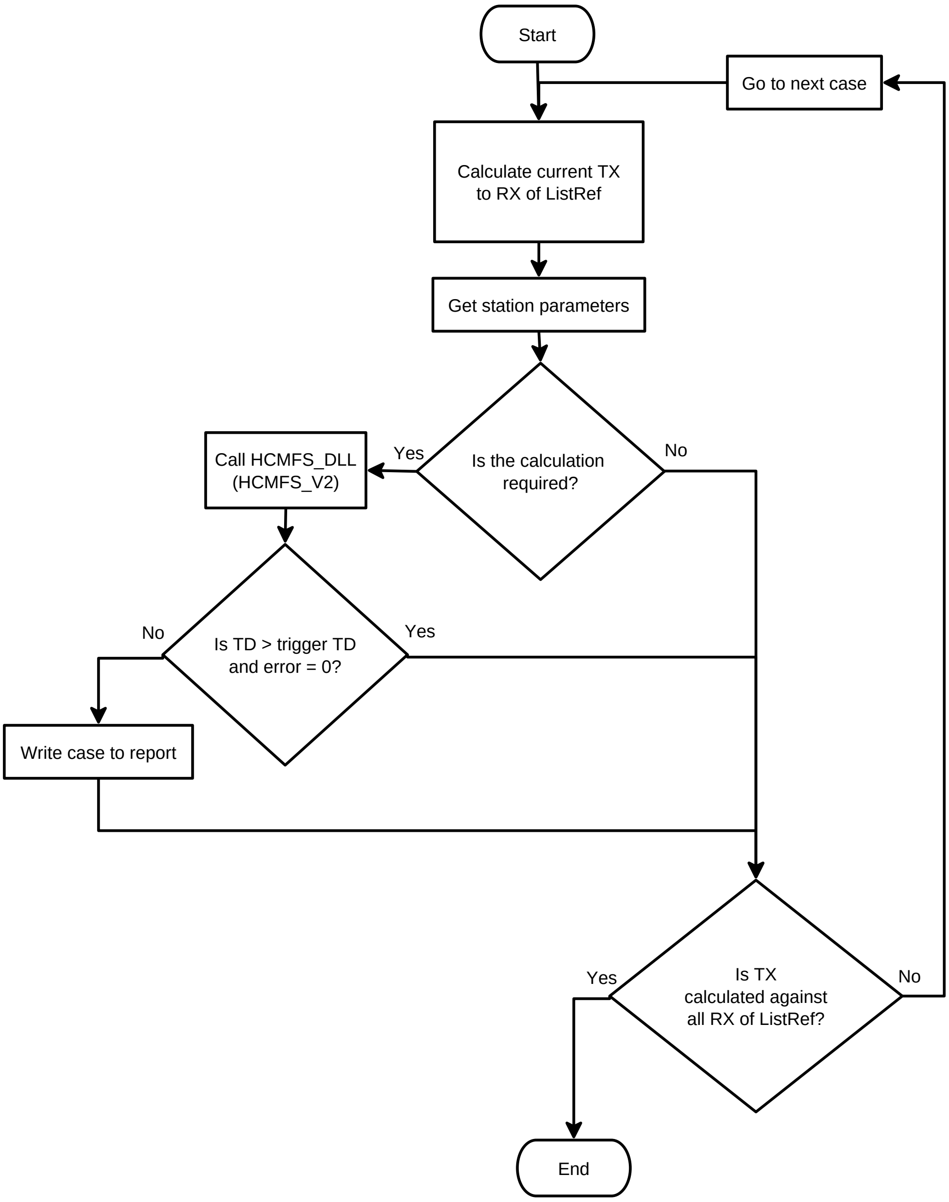
First, interfering transmitter TX is tested against all stations from reference station file.

Next, TX is tested against all stations from reference station file using all passive repeaters from the same reference station file.

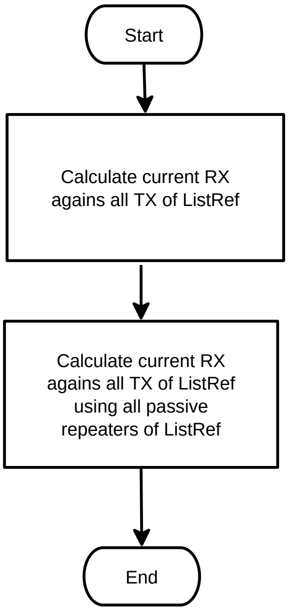
Finally, TX is tested against all receivers of testing file using all passive repeaters from reference station file.

All three cases are very similar to the previous case (calcPTRCase) therefore they will not be described in details. The following diagram explains the first case.

Calculate current TX against all RX of ListRef


Start
Go to next case
Calculate current TX to RX of ListRef
Get station parameters
Is the calculation required?
Yes
No
Call HCMFS_DLL (HCMFS_V2)
Is TD > trigger TD and error = 0?
No
Yes
Write case to report
Is TX calculated against all RX of ListRef?
Yes
No
End

Perform RX calculations (calcRxCase)


Start
Calculate current RX agains all TX of ListRef
Calculate current RX agains all TX of ListRef using all passive repeaters of ListRef
End

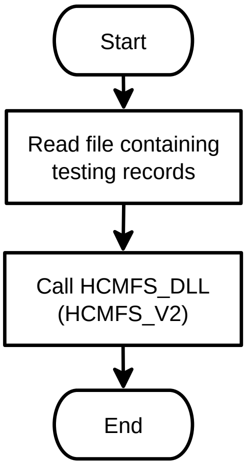
This part consists of two major cases.

First, current interfered-with receiver RX is calculated against all interferers TX of reference station file.

Next, RX is calculated against all TX of reference station file using passive repeaters of this reference file.

Since procedure is very similar to the previous cases it will not be shown here.

3.1.3.2 Single entry calculations


Start
Read file containing testing records
Call HCMFS_DLL (HCMFS_V2)
End

Single entry calculations are very straightforward. The program reads the file submitted by user, and calls HCM calculation library HCMFS_DLL.

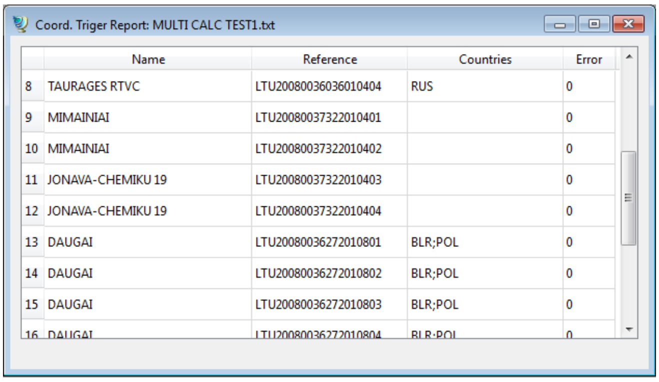
3.2 TRIGGER FOR CO-ORDINATION

The purpose of trigger for co-ordination is to provide user with the information whether stations require co-ordination. Evaluation is performed according to Annex 11 to the HCM-Agreement.

In order to perform such evaluation border data must be present on disk and path to the border data has to be set (see 3.3.1 Paths).

To start calculations activate menu entry *Calculations\Trigger for Co-ordination* or click the button . You will be asked to provide file with the stations formatted according to Annex 2B to the HCM-Agreement.

After calculations are complete the report will be shown.

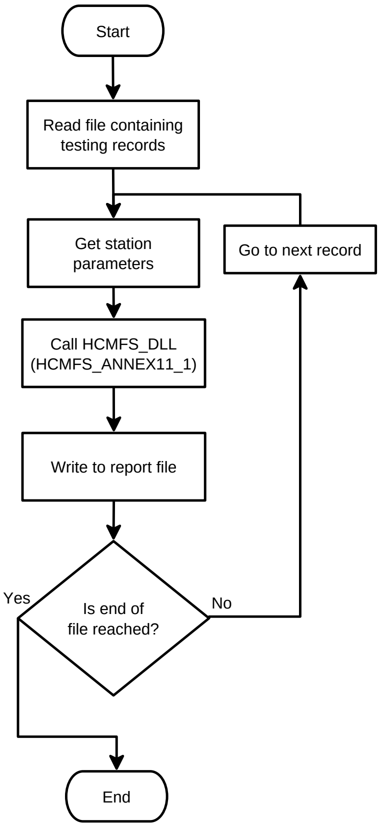


Coord. Triger Report: MULTI CALC TEST1.txt

	Name	Reference	Countries	Error
8	TAURAGES RTVC	LTU20080036036010404	RUS	0
9	MIMAINIAI	LTU20080037322010401		0
10	MIMAINIAI	LTU20080037322010402		0
11	JONAVA-CHEMIKU 19	LTU20080037322010403		0
12	JONAVA-CHEMIKU 19	LTU20080037322010404		0
13	DAUGAI	LTU20080036272010801	BLR;POL	0
14	DAUGAI	LTU20080036272010802	BLR;POL	0
15	DAUGAI	LTU20080036272010803	BLR;POL	0
16	DAUGAI	LTU20080036272010804	BLR;POL	0

The report shows Station name, reference, error code, and countries to coordinate with. If field *Countries* is empty this means that station does not need co-ordination.

3.2.1 Calculation diagram



Read file containing testing records

First, CalcFiSH reads file submitted by user.

Get station parameters

Station parameters are extracted from the file record. This is required in order to fill in the final report.

Call HCMFS_DLL (HCMFS_ANNEX11_1)

This calls the function HCMFS_ANNEX11_1 of HCMFS_DLL and gets the results.

Write to report file

After HCMFS_DLL finishes calculations and presents the results CalcFiSH writes them to the report file.

Is end of file reached?

The program goes through the file records one by one and makes calculations. When all records are evaluated the program finishes its work.

3.3 CALCFISH OPTIONS

CalcFiSH options can be accessed under main menu Tools\Options or by pressing the button 🛠. It contains all available program settings.

3.3.1 Paths

In order to work properly CalcFiSH requires several paths set correctly.

HCMFS calculation library

This is mandatory data defining path to HCM calculation library HCMFS_DLL.

Directory of topological data

This is mandatory data defining path to topological data used by HCMFS_DLL. The result is stored in Windows registry or in the configuration file (for Linux). For more details, see Interface to the surrounding program HCMFS_V2. Since HCMFS_DLL versions less than 2.1.0.0 do not read Windows registry, CalcFiSH will not take this into account when performing calculations. Instead it will search all available disks for TOPO directory and when found, submit its drive letter to HCMFS_DLL.

Directory of morphological data

This path is optional and required only by those countries which are located near a sea. This path is used by HCMFS_DLL. CalcFiSH treats it in the same way as the path to topological data.

Directory of border data

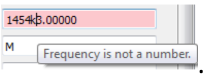
This path is mandatory only for evaluation of the trigger for co-ordination. This path is also used by HCMFS_DLL and is treated by CalcFiSH in the same way as the path to topological data.

3.3.2 Syntax checking

CalcFiSH has a possibility to check HCM file syntax (see 3.5 SYNTAX CHECKING). The following settings are available.

Check syntax while editing file

When checked, CalcFiSH will check syntax while typing. Red colour of the typing area means syntax error, and yellow means warnings. When cursor is positioned under such area, error or warning message is displayed .



1454k3.00000

M

Frequency is not a number.

Check entries required for calculations only

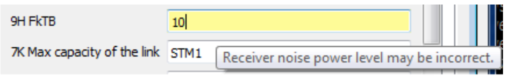
When checked, CalcFiSH looks only at the parameters which are required for calculations. It will check frequency, masks, channel spacing, etc. It will not check station name, frequency category, etc.

Check format of numbers

CalcFiSH checks number format according to Annex 2B to the HCM-Agreement (column 3). For example, format of the frequency is 9(5)V9(5). Therefore CalcFiSH will issue a warning if frequency is set to 14525.452123 (too many digits after the decimal separator).

Show warnings on suspicious values

The program checks some of the numerical values and issues warnings if unrealistic values are found.



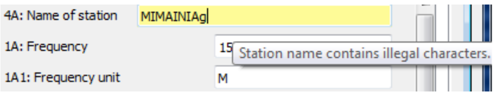
9H FkTB: 10

7K Max capacity of the link: STM1

Receiver noise power level may be incorrect.

Show warnings on illegal characters

If character is found in a non-numerical field, which is not allowed in Annex 2B to the HCM-Agreement, CalcFiSH issues a warning.



4A: Name of station: MIMAINIAg

1A: Frequency: 15

Station name contains illegal characters.

1A1: Frequency unit: M

Show report after file is loaded

When checked, CalcFiSH checks syntax of a file after it is loaded and shows the report if errors are found.

3.3.3 Update

Check for update when program is started

If this option is selected, right after program is started it checks if update for CalcFiSH is available. If this is the case a dialog box of *Download & Update Centre* (see 3.9 DOWNLOAD & UPDATE CENTRE) pops up.

3.3.4 Calculation

There are certain triggers that prevent unnecessary calculations thus speeding up the calculation process.

Perform calculations if the following conditions are met

There are two parameters which trigger calculations. It is frequency difference TX and RX, and distance between TX and RX. If both conditions are met, calculations are performed.

3.4 FILE EDITING

CalcFiSH can create a new HCM-FS file; also can edit one by changing data, adding, duplicating or deleting records.

Create a new file

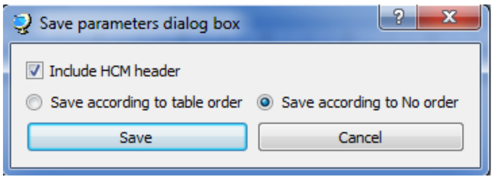
To create a new file, go to *File\New*, or press a button . There is also a shortcut available *Ctrl+N*.

Open an existing file

To open an existing file, go to *File\Open*, or press a button . Shortcut is *Ctrl+O*.

Save a file

To save a file, go to *File\Save*, or press a button . Shortcut to the command is *Ctrl+S*. There is a command *File\Save As* available, which always shows *Save parameters dialog box*.



Save parameters dialog box

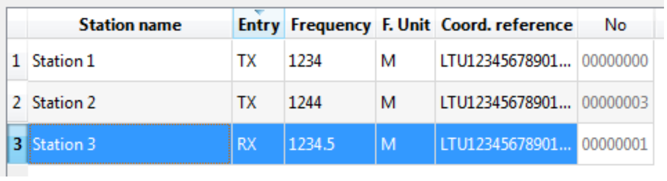
☑ Include HCM header

○ Save according to table order ● Save according to No order

Include HCM header means that when checked, it includes HCM-FS header as a first line to the file. The purpose of this option is to allow user the creation of the HCM-FS file without a header. Such a file can be submitted for *Single entry calculations*, since this type of calculations require HCM-FS file without the header.

Although *Save* command does not show *Save parameters dialog box*, it also does not include HCM-FS header if file being saved does not have one.

Save according to table order saves all records to the file in the same order as they currently appear in the table.



	Station name	Entry	Frequency	F. Unit	Coord. reference	No
1	Station 1	TX	1234	M	LTU12345678901...	00000000
2	Station 2	TX	1244	M	LTU12345678901...	00000003
3	Station 3	RX	1234.5	M	LTU12345678901...	00000001

In the example above, if *Save according to table order* is checked, CalcFiSH will write record of Station 1 first, then record Station 2, then record Station 3.

Save according to No order saves all records in ascending order of the field *No*. In the example above CalcFiSH would write record of Station 1 first, then record of Station 3, then record of Station 2.

Add a record

To add the record, go to *Edit\Add Record* or press the button . Record is always added to the end of the record list.

Delete a record

To delete a selected record, go to *Edit\Remove Records* or press the button ▭ . It is possible to select and delete multiple records at once.

Duplicate a record

To do it, go to Edit\Duplicate Record or press the button ⧉. Multiple records can be duplicated. Duplicated records always appear at the end of the record list.

3.5 SYNTAX CHECKING

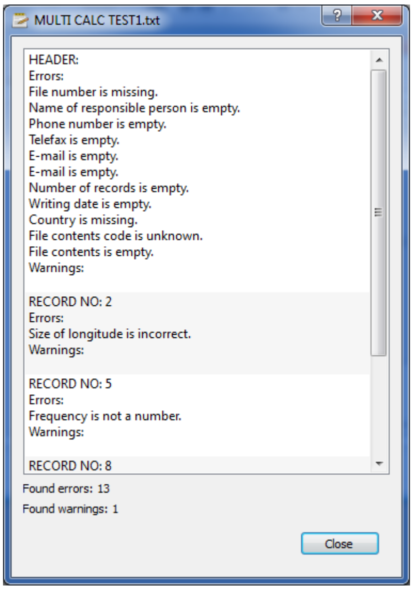
CalcFiSH performs syntax checking according to the rules of Annex 2B to the HCM-Agreement. Additionally it warns user when unrealistic values of numerical data are found.

When syntax check is being performed CalcFiSH produces messages of errors and warnings.

Error messages have to be dealt with because they mean rather serious problems with the data, which may influence calculation result, while warnings just inform the user that there might be a problem with the data but this may not influence calculation result. For example, if station name or equipment type contains lower case letters CalcFiSH can produce a warning that illegal characters are used but this no way will influence calculation result.

CalcFiSH can check file syntax while typing. Errors or warnings are indicated by changing background colour of the data field. Red colour means an error 024E6242, while yellow colour means a warning 4A: Name of station Station 2 .

After syntax check is finished the report is shown to the user.



HEADER:
Errors:
File number is missing.
Name of responsible person is empty.
Phone number is empty.
Telefax is empty.
E-mail is empty.
E-mail is empty.
Number of records is empty.
Writing date is empty.
Country is missing.
File contents code is unknown.
File contents is empty.
Warnings:

RECORD NO: 2
Errors:
Size of longitude is incorrect.
Warnings:

RECORD NO: 5
Errors:
Frequency is not a number.
Warnings:

RECORD NO: 8

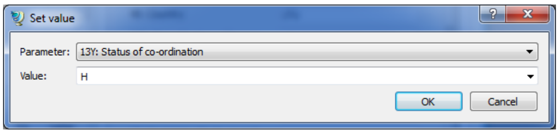
Found errors: 13
Found warnings: 1

By double-clicking on the error/warning entry in the report CalcFiSH selects the appropriate record in the file thus making it easier for the user to look for the error.

User can choose whether he wants to see warning or not. There are also more options available for the user to set. More information on this can be found in 3.3.2 Syntax checking.

3.6 CHANGING DATA AUTOMATICLY

When the HCM-FS file is opened the user can select several records and go to *Edit\Set Value* or click the button. This will open *Set Value* dialog box.



Parameter: 13Y: Status of co-ordination

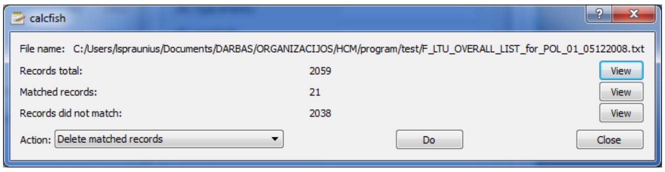
Value: H

Currently there is a possibility to change data of the fields 13Y (Status of co-ordination) and 2Z (Final date of achieving co-ordination) for all selected records.

3.7 FILE COMPARISON

CalcFiSH has the possibility of comparing two HCM-FS files and performing some actions on them.

First, open a file. When it is opened go to *Edit\Compare with Auxiliary file* or click the button, then select a second (auxiliary) file to compare with. Dialog box showing the comparison results will pop up.



File name: C:/Users/lspraunius/Documents/DARBAS/ORGANIZACIJOS/HCM/program/test/F_LTU_OVERALL_LIST_for_POL_01_05122008.txt

Records total: 2059

Matched records: 21

Records did not match: 2038

Action: Delete matched records

File name is the name of the auxiliary file.

Records total – number of the records of the auxiliary file.

Matched records is the number of the records of the auxiliary file having identical *Co-ordination reference* as the records of the opened file. It does not mean that all data of those records of auxiliary file are identical to the ones from the opened file. This means that only *Co-ordination reference* is identical.

Records did not match is the number of records of the auxiliary file that do not match records of the opened file.

View buttons let the user view some of the details of the appropriate records of the auxiliary file.

Action

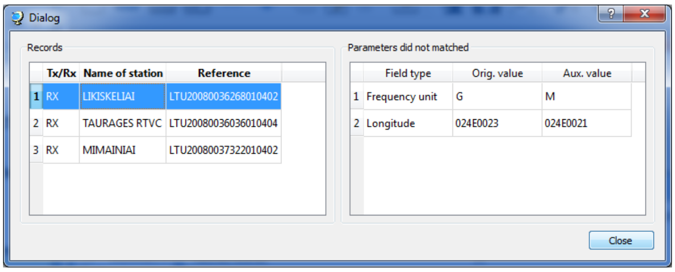
There are several actions available. Please note that all the actions are performed on the opened file.

Action *Delete matched records* deletes all the records from the opened file that are identical to the ones of the auxiliary file.

Action *Append not matched records* adds all not matched records of the auxiliary file to the opened file.

Action *Replace matched records by ones from the file* will replace all records of the opened file with the records of the auxiliary file which have the same *Co-ordination reference*.

Action *Detailed comparison of the matched records* makes detailed comparison of the records with identical *Co-ordination references*.



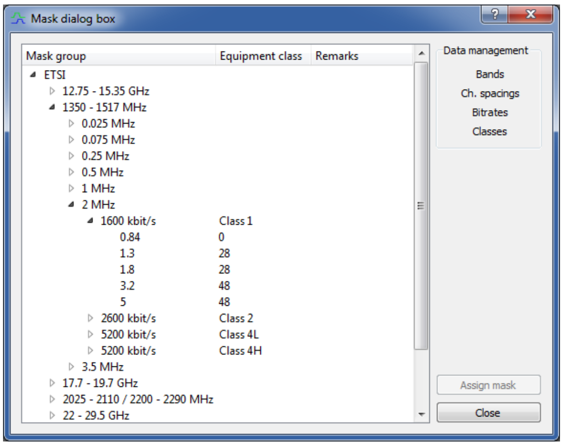
	Tx/Rx	Name of station	Reference
1	RX	LIKISKELIAI	LTU20080036268010402
2	RX	TAURAGES RTVC	LTU20080036036010404
3	RX	MIMAINIAI	LTU20080037322010402

	Field type	Orig. value	Aux. value
1	Frequency unit	G	M
2	Longitude	024E0023	024E0021

3.8 TRANSMITTER AND RECEIVER MASKS

CalcFiSH has a database of transmitter and receiver masks. It can be accessed by going to *Tools\TXRX Masks* or by clicking the button. *Mask dialog box* contains two main parts. One contains all mask data, while the other manages basic data such as equipment classes, channel spacing, bitrates.

Mask data is stored in the file equipment.db, which is located in the main CalcFiSH directory. This is Sqlite file, therefore it also can be opened by any data management program which supports Sqlite databases.



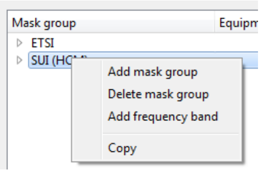
```
Mask group                    Equipment class   Remarks
◢ ETSI
   ▷ 12.75 - 15.35 GHz
   ◢ 1350 - 1517 MHz
      ▷ 0.025 MHz
      ▷ 0.075 MHz
      ▷ 0.25 MHz
      ▷ 0.5 MHz
      ▷ 1 MHz
      ◢ 2 MHz
         ◢ 1600 kbit/s         Class 1
              0.84             0
              1.3              28
              1.8              28
              3.2              48
              5                48
         ▷ 2600 kbit/s         Class 2
         ▷ 5200 kbit/s         Class 4L
         ▷ 5200 kbit/s         Class 4H
      ▷ 3.5 MHz
   ▷ 17.7 - 19.7 GHz
   ▷ 2025 - 2110 / 2200 - 2290 MHz
   ▷ 22 - 29.5 GHz
```

Masks can be changed, added, or removed. Please keep in mind that when CalcFiSH is updated, mask data file is backed up before it is replaced by the new one. Therefore you can restore your mask data by renaming your backup file back to equipment.db.

All masks belong to the mask groups. For example, all ETSI masks are stored under mask group ETSI.

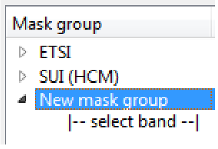
The following example shows how to create new masks along with the new mask group.

First, create a mask group. Select an existing mask group, right-click it. In the context menu choose *Add mask group*.

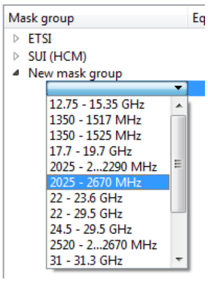


It will create a new mask group named <- *New* ->. Double-click on it to rename.

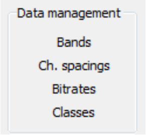
Select the created mask group, right-click for the context menu, then *Add frequency band*.



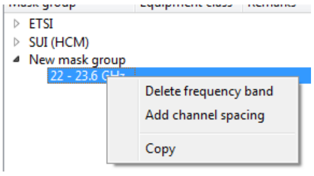
Double-click on *|-- select band --|*. Combo box will appear with the list of all available frequency bands. Choose the required frequency band.



In case the required frequency band is not available, it can be created by clicking on *Bands* under *Data management*.

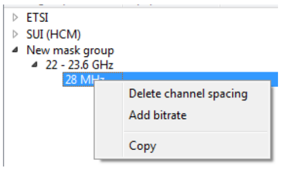


When the right band is chosen, context menu on the selected band will allow to *Add channel spacing*.

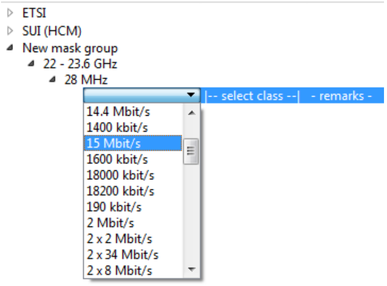


Double-click on the created channel spacing to select a required value from the list. If required value is missing it can be created by clicking *Ch. spacing* under *Data management*.

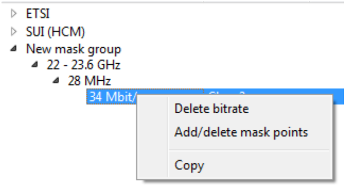
Context menu on the created channel spacing will allow to *Add bitrate*.



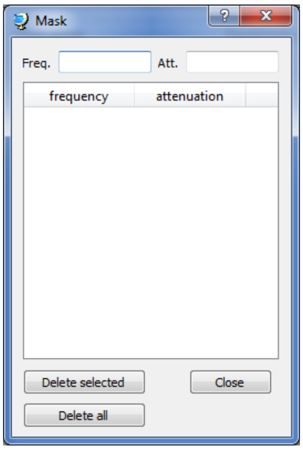
When created, it requires setting of appropriate values for the bitrate, and equipment class. Also remarks are available.



The final step is to add mask data. This is done by invoking a context menu on this record and clicking on *Add/delete mask points*.



In the appeared Mask dialog box mask data points can be added, and deleted.



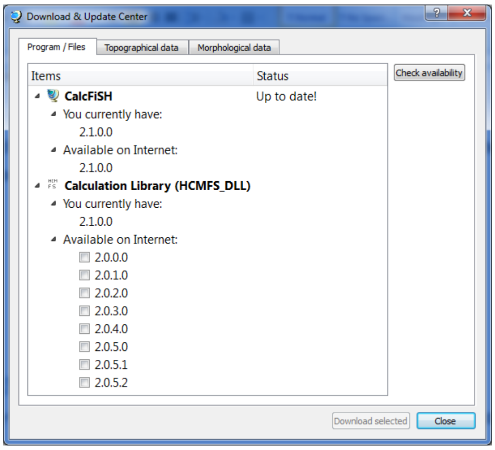
3.9 DOWNLOAD & UPDATE CENTRE

Download &Update Centre can be used to update the program, and the HCMFS_DLL. It also can download topological and morphological data from the internet.

The centre can be invoked by going to *Tools\Download Update Centre*.

3.9.1 Updating CalcFiSH and HCMFS_DLL

In the open dialog box click *Check availability* button to check what is available on internet. After that the dialog window should look something like that:



Download & Update Center

Program / Files | Topographical data | Morphological data

Items | Status
CalcFiSH | Up to date!
You currently have:
2.1.0.0
Available on Internet:
2.1.0.0
Calculation Library (HCMFS_DLL)
You currently have:
2.1.0.0
Available on Internet:
□ 2.0.0.0
□ 2.0.1.0
□ 2.0.2.0
□ 2.0.3.0
□ 2.0.4.0
□ 2.0.5.0
□ 2.0.5.1
□ 2.0.5.2

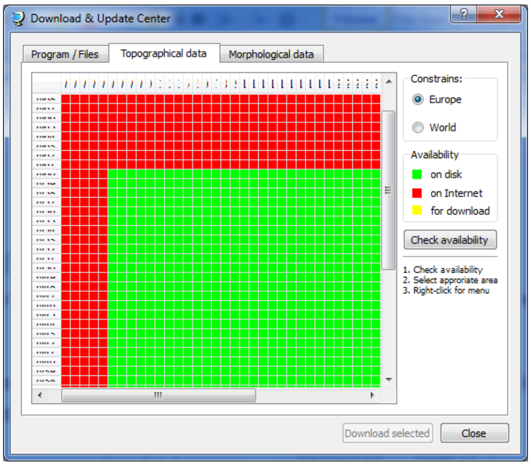
In the picture above it is shown that the user has CalcFiSH version 2.1.0.0, and the same version is available on internet. Therefore there is no need for updating it.

If a new version is available, checkbox will appear at the left of CalcFiSH. Select it and click *Download selected*.

Dialog box window also shows HCMFS_DLL currently used by CalcFiSH and available on internet. To download a new HCMFS_DLL, select appropriate checkbox and click *Download selected*.

3.9.2 Downloading topological and morphological data

To download topological data go to *Topological data* tab, then click *Check availability* button. This will check topological data available on your hard disk. Please keep in mind that path to the topological data has to be set under Tools\Options before checking. When check is complete, data availability is shown on the window in red and green colours.



Download & Update Center

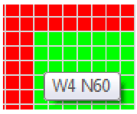
Program / Files | Topographical data | Morphological data

Constrains:
● Europe
○ World

Availability
🟩 on disk
🟥 on Internet
🟨 for download

1. Check availability
2. Select approriate area
3. Right-click for menu

Green colour means that data is on the disk. To check the details on available data put cursor over certain data square. Information on latitude and longitude will pop up.



W4 N60

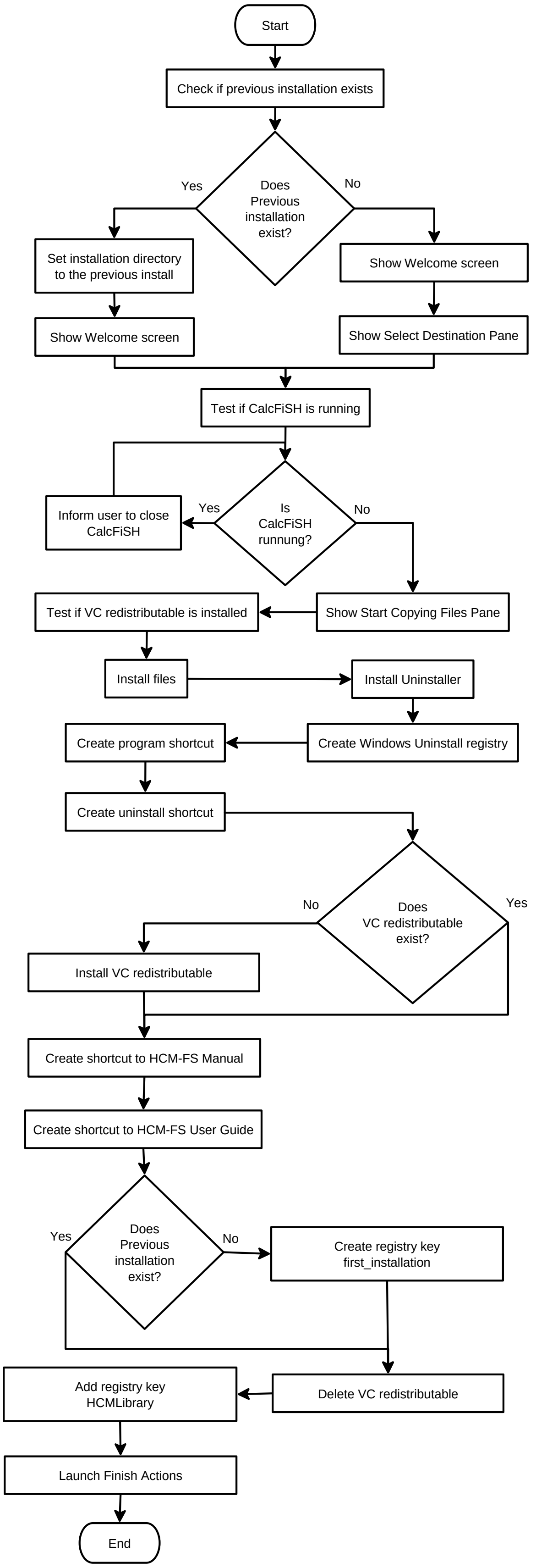
To select certain area for download left-click on certain data square and move the mouse while the button is pressed, then right-click on the selected area and choose *Select for download*. There is also possibility to dismiss selected areas or delete data from your hard disk.

After you selected certain area for download it get its colour changed to yellow. When all required areas are selected click *Download selected*. All selected data will be downloaded and installed on the computer.

Downloading of morphological data looks exactly the same as topological.

3.10 INSTALLER

For building the CalcFiSH installer InstallJammer (http://www.installjammer.com) is used. Main installation procedure is shown on the following flowchart.


Start
Check if previous installation exists
Does Previous installation exist?
Yes
No
Set installation directory to the previous install
Show Welcome screen
Show Welcome screen
Show Select Destination Pane
Test if CalcFiSH is running
Inform user to close CalcFiSH
Yes
Is CalcFiSH runnung?
No
Test if VC redistributable is installed
Show Start Copying Files Pane
Install files
Install Uninstaller
Create program shortcut
Create Windows Uninstall registry
Create uninstall shortcut
No
Does VC redistributable exist?
Yes
Install VC redistributable
Create shortcut to HCM-FS Manual
Create shortcut to HCM-FS User Guide
Yes
Does Previous installation exist?
No
Create registry key first_installation
Add registry key HCMLibrary
Delete VC redistributable
Launch Finish Actions
End

Although installation diagram seems rather sophisticated, it is quite simple. CalcFiSH installation file usually has the name CalcFiSH-X.X.X.X-Setup, where X.X.X.X is version number. When launched it checks if CalcFiSH is already installed. It will detect only CalcFiSH versions greater than 2.1.0.0 by the application ID which in CalcFiSH case is 12C5A267-D3C4-4586-8475-52BCA774665D. If the old installation is found installer sets installation directory to the old one and will not allow user to select other directory.

The installer then checks whether CalcFiSH is running and warns user about that. It will not continue further unless user closes CalcFiSH.

After CalcFiSH is closed installer checks whether Visual C (VC) redistributable is installed on the computer. The redistributable package is required in order to run CalcFiSH. This checking is followed by file installation during which files are being copied to the installation folder.

After files are copied appropriate actions are done to create uninstaller, and program shortcuts.

If VC redistributable does not exist on the system it is being installed.

If previous installation does not exist installer creates a registry key *first_installation* which shows CalcFiSH that this is the first installation and user must set appropriate paths in order to work with it.

After this VC redistributable package is removed from the installation directory, and a key HCMLibrary is created to point to the new installed HCMFS_DLL.

4. STORAGE FORMAT OF HEIGHT DATA

The height data used by the HCM programs (Mobile Service and Fixed Service) may come from different sources.

Some data may come from military source (Digital Terrain Elevation Data (DTED) Level 1 Coverage), some data may come from national geographic institutes.

A fall-back possibility to get terrain height data is to use GTOPO30 or SRTM3 data. This data is free of licence. Converted GTOPO30 and SRTM3 data is available at the internet site of the HCM-Agreement (http://hcm.bundesnetzagentur.de).

The HCM terrain height data has a resolution of 3 seconds in the North - South direction and 3 or 6 seconds in the East – West direction (depending on the latitude). If the latitude is less than 50 degrees (North or South), the resolution is 3 seconds, if the latitude is greater or equal to 50 degrees, the resolution is 6 seconds.

All source data has to be converted to WGS84 format and to the above mentioned resolution. Data from different sources needs to be combined to a common database covering all HCM-Agreement Signatory countries (plus an additional range of approximately 100 km).

The storage format of this data is:

- All elevation data consists of 2 Bytes Integer-values (Fixed Binary integers). If the elevation value is negative, first the MSB (Bit #15) has to be cleared and second the complement has to be built to get the correct elevation value.

- Terrain data of a 5 x 5 minute square (approximately 9 x 5 km) is combined in one data-record. Strips in the North and East are added to the data inside the square. The reason is: If you want to have the elevation of a given point, in most cases this point is located between 4 points in the grid of the stored data. To get the correct elevation, you have to interpolate between these 4 points. The western and southern grid-points are always present (example: wanted point 8 degrees 0 minute 1 second → record 8 degrees 0 minute to 5 minutes is read; so the western grid-point (= 8 degrees 0 minute 0 second) is present. In the case where the wanted point is for example 8 degrees 4 minutes 59 seconds, the eastern grid-point is 8 degrees 5 minutes 0 second. Normally this point is not inside the read record, but part of another record (8 degrees 5 minutes to 10 minutes). To prevent the program from reading an additional record, the strip 5 minutes 0 second is added to the record 0 minute to 5 minutes. For the same reason, a strip in the North is also added. It is therefore possible to get the right elevation of a wanted point reading only one record of data.
- 12 x 12 records (=144 records=1 x 1 degree) are stored in one file.
- The filename is (example): E007N50.63E

  Where

  E007 = longitude of the South-West corner,

  N50 = latitude of the South-West corner,

  63 = resolution in seconds longitude (6) and latitude (3) and

  E = elevation data (M for morphological data).
- Position of records inside the file:

	133	134	135	136	137	138	139	140	141	142	143	144	
	121											132	
	109											120	
	97											108	
	85											96	
	73											84	
West	61											72	East
	49											60	
	37											48	
	25											36	
	13											24	
	1	2	3	4	5	6	7	8	9	10	11	12	

- All files with the same longitude are stored in the same subdirectory. The name of the subdirectory is equal to the first four characters of the filename (example: E007).

- All subdirectories are stored in the (top level) directory. For the fixed service the directory can be either TOPO, if Windows registry key or PATH.DAT is not used, or any other directory, if registry key HKEY_LOCAL_MASHINE\Software\HCM\topo or PATH.DAT is used for defining path to the top level directory. A valid filename with the full path therefore is:
  C:\TOPO\E010\E010N45.33E (if registry key is not used), or
  C:\Data\topographical data\E010\E010N45.33E (if registry key or PATH.DAT is used having value C:\Data\topographical data).
- In Europe, a 5 minutes x 5 minutes square contains north of 50 degrees latitude 101 x 51 values = 5.151 values and south of 50 degrees latitude 101 x 101 values = 10.201 values. One value = 2 Bytes. The length of data records therefore is 10.302 or 20.402 Bytes.
- Record description:
  Length: fixed, 10.302 or 20.402 Bytes
  No carriage control!
- The elevation data inside the record is combined from East to West and from South to North.
  Example: (South of 50 degrees latitude, resolution in East-West-direction = 3 seconds; number of elevation data)

North

West

10101	10102	10103			10200	10201
10000	10001	10002			10099	10100
102	103	104			201	202
1	2	3			100	101

East

5. STORAGE FORMAT OF MORPHOLOGICAL DATA

The morphological data required for the HCM programs is provided by the TWG HCM SWG Program (Technical Working Group Harmonized Calculation Method Sub Working Group Program) and is available at the internet site of the HCM-Agreement (http://hcm.bundesnetzagentur.de).

The data is elaborated using GTOPO30 data.

The morphological database is a raster database with the same grid and structure as the terrain height database (see Chapter 4).

Each entry consists of two bytes, one for the predominant height of the surface (trees, buildings) and one for the class of the morphology information.

Because each grid point represents an area of 3 x 3 (3 x 6) seconds, more than one class of morphology is possible, e.g. a part is buildings, another part is trees. In those cases there are different heights for this area. It is possible, to define more than one class, but only one height.

The height information is one byte. Therefore it is possible to define heights from 0 m to

255 m. The height is the predominant height of the area represented by this grid point, e.g. if there are 70 % buildings with 10 m height, 20% trees with 12 m height and 10% roads with 0 m height, 10 m is taken to represent this area.

The class of morphology consists of one byte. Therefore 8 different classes (bits) are possible. For the fixed service land, sea and coastal area are required, for the mobile service only land and sea are required.

-	all bits are 0	normal land
-	bit 0 is 1	sea, ocean
-	bit 1 is 1	small lake, river, small portions of water (no sea, no ocean!)
-	bit 2 is 1	coastal area
-	bit 3 is 1	villages, towns (buildings)
-	bit 4 is 1	trees
-	bits 5 to 7	for future use

In general, a morphological database is not required for all countries applying the HCM software. If there is no sea or coastal area (e.g. Austria, Slovakia), the use of a morphological database is not mandatory. If no MORPHO data is available, HCM software sets all morphological information to “normal land”.

The morphological database offered by the TWG HCM SWG Program does not have height information (all heights are 0 m). Only the morphological classes ‘normal land’, ‘sea / ocean’ and ‘costal area’ are supplied.

All morphological data consists of 2 bytes. The first byte represents the class of morphology, the second byte is the height information.

Morphological data of a 5 x 5 minutes square (approximate 9 x 5 km) is combined in one data-record.

- 12 * 12 records (=144 records;=1 * 1 degree) are stored in one file.
- The filename is (example): E007N50.63M

Where	E007	=	longitude of the South -West corner,
	N50	=	latitude of the South -West corner,
	63	=	resolution in seconds longitude (6) and latitude (3) and
	M	=	Morphological data (E for elevation data)

- Position of records inside the file:

North

	133	134	135	136	137	138	139	140	141	142	143	144	
	121											132	
	109											120	
	97											108	
	85											96	
	73											84	
West	61											72	East
	49											60	
	37											48	
	25											36	
	13											24	
	1	2	3	4	5	6	7	8	9	10	11	12	

South

All files with the same longitude are stored in the same subdirectory. The name of the subdirectory is equal to the first four characters of the filename (example: E007).

All subdirectories are stored in the (top level) directory. For the fixed service the directory can be either MORPHO, if Windows registry key or PATH.DAT is not used, or any other directory, if registry key HKEY_LOCAL_MASHINE\Software\HCM\morpho or PATH.DAT is used for defining path to the top level directory. A valid filename with the full path therefore is:

C:\MORPHO\E010\E010N45.33M (if registry key is not used), or
C:\Data\morphological data\E010\ E010N45.33M (if registry key of PATH.DAT is used having value C:\Data\ morphological data).

In Europe, a 5 x 5 minutes square contains north of 50 degrees latitude 101 x 51 values = 5.151 values and south of 50 degrees latitude 101 x 101 values = 10.201 values. One value = 2 bytes. The length of data records therefore is 10.302 or 20.402 bytes.

Record description:

Length: fixed, 10.302 or 20.402 Bytes

No carriage control!

The data inside the record is combined from East to West and from South to North.

Example: (South of 50 degrees latitude, resolution in East-West-direction = 3 seconds; number of morphological data)

North

West

East

10101	10102	10103			10200	10201
10000	10001	10002			10099	10100
102	103	104			201	202
1	2	3			100	101

6. STORAGE FORMAT OF BORDERLINE DATA

Fixed service uses borderlines stored with the extension '.all'. First part of the file name contains country code (HOL.all, I__.all, etc.). These files contain borderline data of the appropriate country. An administration should have such files for all its neighbours.

Line data files consist of fixed length records without carriage control.

To create a record, the co-ordinates of 10 points following each other are selected. The centre of this 10 co-ordinates is calculated. This is the 11th point. All co-ordinates are in decimal form, longitude first, latitude second (e.g. 10.14567 45.39876). The result of all 11 points is 22 numbers. This 22 values are converted to radian (value x π / 180) and stored in REAL x 8 variables. All converted 22 values are stored in one record writing 22 x 8 = 176 Bytes.

Record: long 1, lat 1, long 2, lat 2,…..long 10, lat 10, long11, lat11

Part of a FORTRAN code to store the data (22 radian values of co-ordinates)

```
        PROGRAM TEST
C
        DOUBLE PRECISION        COORD(22)
        CHARACTER*176           LINE
C
        EQUIVALENCE (COORD, LINE)
C
```

```
                  OPEN (UNIT=1, FILE='HOLBEL.000', ACCESS = 'DIRECT', RECL = 176)
                  WRITE (1, REC=1) LINE
C
C                 LINE and COORD use the same memory space (EQUIVALENCE statement) !
C
                  CLOSE (UNIT=1)
C
                  END
```

If for the last record the number of the remaining points is less than 10, the co-ordinates of the last available point is duplicated until 10 co-ordinates are reached.

The task of creating the files with line data is part of the BORDER program, which is available on the internet site of the HCM-Agreement.