AVAL 6.6

User Manual Maps

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Maps

January 2008

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1 Map

1.1 General

All scenes in the Indirect Fire and Minefield modes are defined in a map, which is read into AVAL as a map file in a bitmap format (TIFF, GIF, JPEG, PNG or BMP). The colour information in the bitmap file is used to define terrain category.

When creating a scene, at the first time a map is used a modified map file is created. This map file is named as the original map file with the addition of _TERRAIN. This so called "terrain map" supports to clearly identify the terrain category.

As a complement to the bitmap file following additional data must or can be added to the scene environment:

- Map data.
- Map symbols.
- Height data (optional).
- Environment protection data (optional).

All data are stored in a number of files, described in details later in this document:
- Map file and terrain map file
- Map data file
- Symbols file
- Height data base file
- Environment protection file

1.2 Coordinate systems

AVAL assumes that the map is defined with the upper part to the north, .x-coordinates increasing upwards and to the north and y-coordinates increasing rightwards (to the east). Height values must increase upwards from see level.

1.3 Map data

Each map file used in a scene must be coupled to a map data file (*.*dat*) with information of the map position in the coordinate system and the size of the map. The map data file also contains a list of terrain categories to be used for terrain protection.

The file has following format:
- X and Y-value of the lower left corner.
either:
- Meters for each pixel in the bitmap file.
or.
- X and Y-value of the upper right corner.
After that follows one row for each terrain category containing:

- Category code
- Red value of the RGB-colour.
- Green value of the RGB-colour.
- Blue value of the RGB-colour.
- Category name.

The RGB values for a colour in a map file can be obtained i.e. from Microsoft Paint.

Example of a map data file:

```
6575000.0      1425000.0
5.0
! Categorie code, R, G, B, 'Category name'
 1     175 236 181    'skog'
 2     222 254 226    'lövskog'
 3     149 186 249    'sjö'
 4     252 244 166    'åker'
 5     255 255 255    'öppen mark'
 6     215 161 136    'mosse'
 7     214 147 37     'väg'
 8     220 219 220    'industri'
 9     249 159 218    'bebyggelse'
10     209 110 186    'hög bebyggelse'
11     255 190 230    'fritidsbebyggelse'
12     190 224 252    'våtmark'
```

Figure 1 Example of a map data file

1.4   Terrain map

Terrain protection is included in the ballistic calculation of fragments from fragmenting warheads.

Terrain protection can only be coupled to those terrain categories defined in the map data file described above and the terrain map. The terrain map can only contain the colours for the defined terrain categories and will be created when the original map is read into AVAL. The terrain file will be saved in the same format as the original bitmap file with an additional _TERRAIN to the name.

When creating the terrain file the original bitmap file will be searched pixel by pixel and pixels with undefined colours will be replaced with a colour of the nearest pixel with a defined colour. This is quite time consuming but if a terrain file already exists in the same directory as the original file it will be read instead of calculating a new one.

If the map data file is altered regarding to terrain categories or colours any existing terrain bitmap file must be removed to force AVAL to calculate a new one.

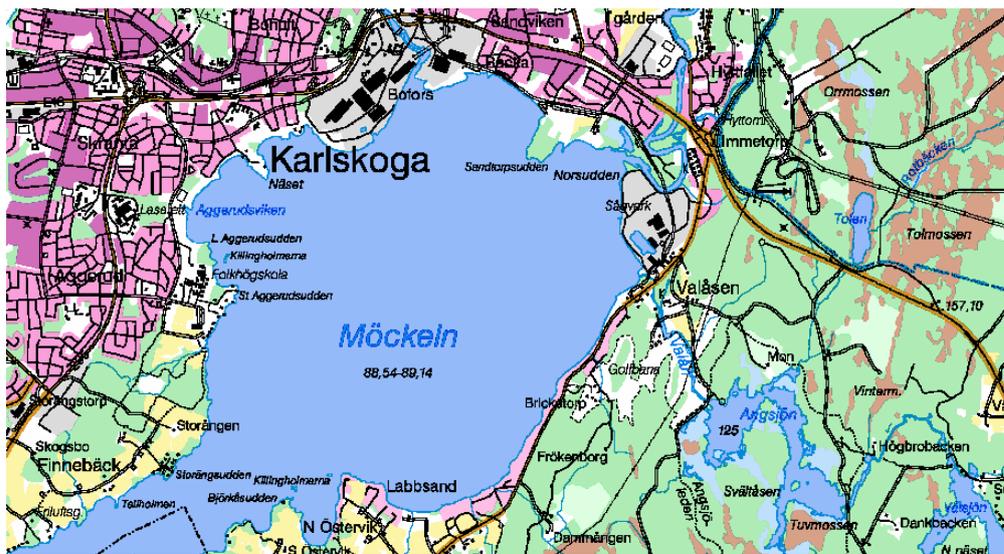Below is shown an example of an original map and a created terrain map.
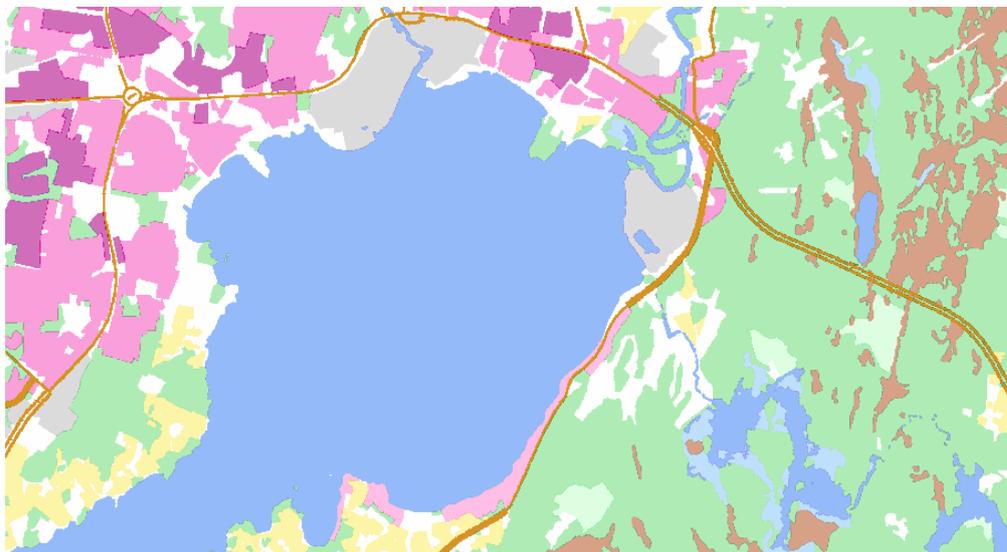
Figure 2 Original map.

Figure 3 AVAL calculated terrain map.

1.5 Map symbols

All objects inserted to the scene is shown with a symbol and these symbols must be loaded to AVAL in order to draw them in the map. Each symbol to use is defined as bitmap file and can be shown in selected size and transparent if wanted. If the transparent option is selected the white colour of the symbol bitmap is made transparent.

Each image in the symbol file will show up in the symbol dialog with their file name without the extension.

The bitmap symbols can be created in a bitmap editor such as Paint and saved in any of TIFF, GIF, JPEG, PNG or BMP-format. To ensure the transparency function though PNG-format is, for an unknown reason, the only format that works.

The size of a symbol is set in pixels and the original image will be scaled to the selected symbol size. If the original image does not have the same height as width (in pixels) the

selected symbol size will be set to the largest of height and width and the other one will be less than selected symbol size.

1.6 Height data

1.6.1 General

The map data contains no height data, which must be read into the Indirect fire scenes and Minefield scenes separately.

Adding height data to a scene is optional and if omitted the ground is assumed to be plane with the height 0.0.

The height data must have the ASCII standard format provided from the Swedish authority "Lantmäteriet". A height database can easily be created by following the instructions below.

Height data has x-min in the south most coordinate, y-min in the west most coordinate and all heights above see level are positive.

A map file and a height data file do not have to cover the exact same area from a formal point of view. However, if the height data is to be included in the calculations, they must both cover the area of interest. If calculations are made outside the area of the height database, the height 0 m will be used.

1.6.2 Height data base format

Figure 4 Example of height data base format.

The first row includes from the left		Example:	Format:
A=	Map name	4C7G	(10 pos.)
B=	x-min for the data base:	6285000.0	(10 pos.)
C=	y-min:	1330000.0	(10 pos.)
C=	y-min:	1330000.0	(10 pos.)
D=	x-max:	6290000.0	(10 pos.)
E=	y-max:	1335000.0	(10 pos.)
F=	Distance between points in x and y direction:	50.0 50.0	(7+7 pos.)
G=	Number of points in x and y direction:	101 101	(4+4 pos.)

Second row:

1 57.4 62.7 63.7 61.0 57.0 56.4 56.7 57.0 57.1 57.3 57.7 58.0

1 indicates the first row (7 pos.). Rows are given from south to north.

Then follows all heights in row 1, given from west to east (7 pos.).

The first height in the file is consequently the lower left point in the map.

Example:

Figure 5 Coordinate system for height data base.

2 Environment protection

2.1 General

Environment protection from ground objects can be described for different terrain categories in terms of a reduction of fragment penetration capacity.

Each terrain category in the map data can be connected with a protection type defined in an environment protection file (*.*evp*). Several terrain categories can have the same protection type.

2.2 Defining environment protection

2.2.1 Setting environment protection

The dialog for handling environment protection is opened with **Scene -> Environment protection** in the menu.

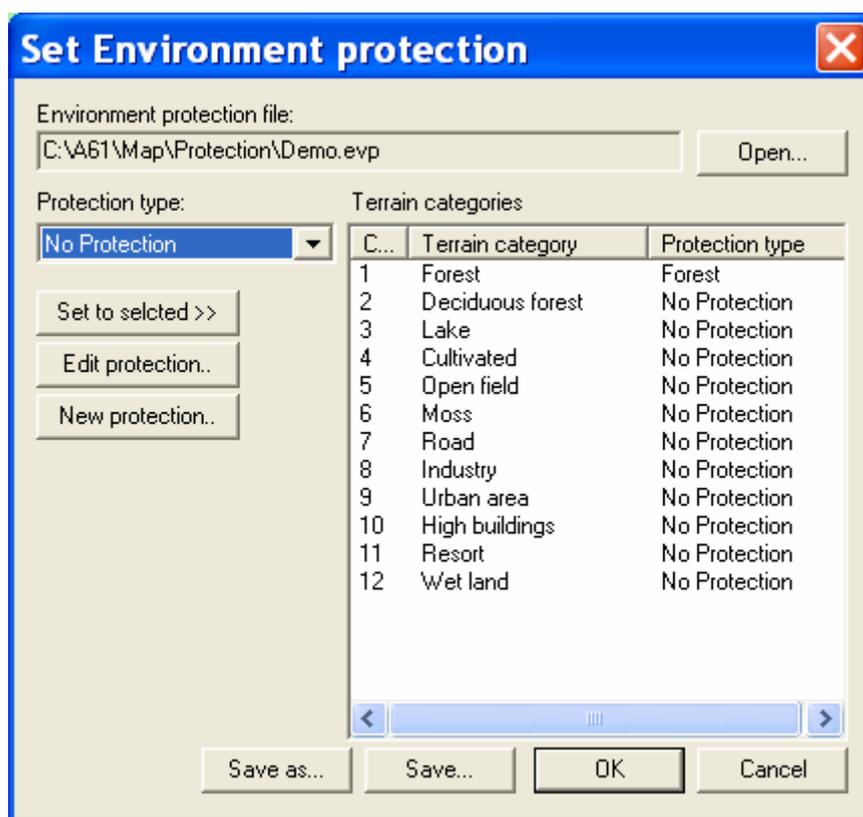Figure 6 Set environment protection dialog box.

Open…	To open an *.evp*-file with predefined environment protection.
Protection type:	Available protection types to use.
Terrain categories:	Terrain categories from the map, possible to connect to a protection type.
Set to selected>>	Connect selected Protection type with selected terrain categories.

Edit protection..	Open the dialog to edit selected protection type in the dialog Define environment protection.
New protection..	Open the dialog to define a new protection type in the dialog Define environment protection.
Save.../Save as..	Save environment protection data to new or current file (*.evp*).
OK	Close the dialog and use *.evp*-file data in current scene.
Cancel	Close the dialog without using *.evp*-file data in current scene.

2.2.2   Defining a protection type

Clicking **Edit protection** or **New protection** opens the dialog Define Environment Protection.

The protection type is given a name and protection data are given. For protection method 1, the data are described as reduction of fragment penetration capacity /m travelled distance for the fragment.

By using protection method 2 environment protection is calculated in a user described terrain.

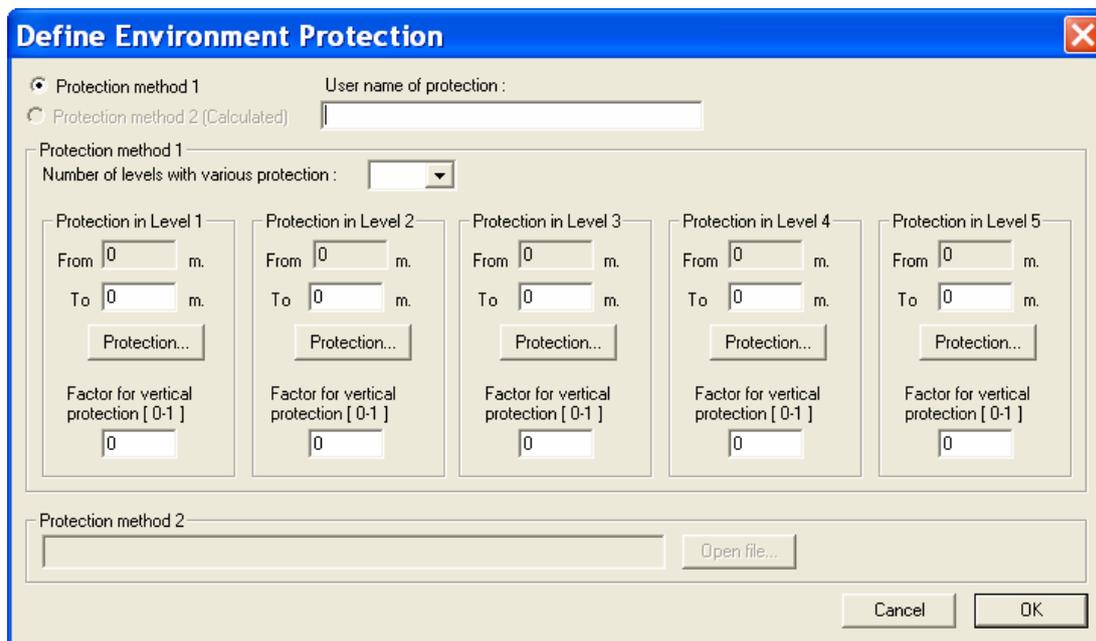**Protection method 1**

Figure 7 Define environment protection, method 1, dialog box.

Each protection type can be described in up to five height levels over ground with different protection data.

For each level is given the upper and lower boundary in m over ground, the horizontal protection within the interval and a correction factor for vertical protection compared to the horizontal protection.

The horizontal protection for each interval is given with pair values for probability and protection. The actual protection used in the simulation will be randomized from these values.

The protection is given as m penetrated mild steel /m travelled distance for the fragment.
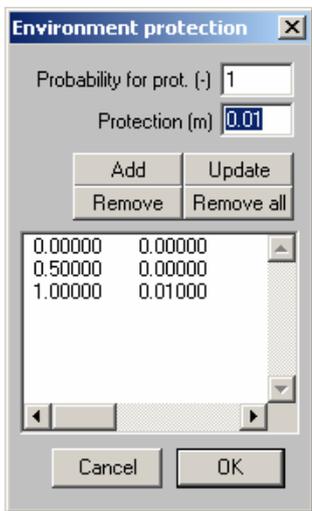

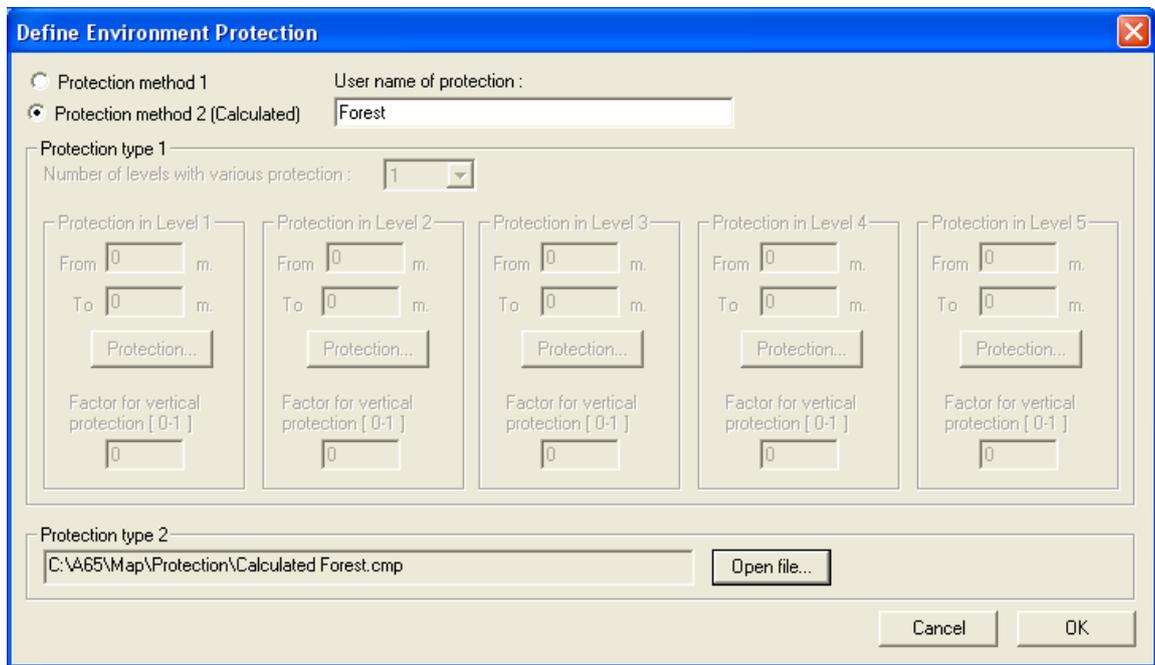Figure 8 Environment protection dialog box.

Protection method 2

Figure 9 Define environment protection, method 2, dialog box.

If the protection method 2 checkbox is selected the only input data is the file path to the calculated map protection file.

Example of an environment protection file (*.evp*) where the first protection type is of type 1 and the second of type 2:

```
   4      20.0   ! n x n elements and size of each element
   2         ! Number of environment protection types
'Forrest'       ! User description
   3        ! Number of levels with various protection
0.00      0.50      ! from and to z level for protection
   3 !Number of pair values
   0.0000    0.0000
   0.5000    0.0000
   1.0000    0.0100
0.10       ! Factor for protection to use in vertical direction
0.50      2.00       ! from and to z level for protection
   3 !Number of pair values
   0.0000    0.0000
   0.8000    0.0100
   1.0000    0.0100
0.30       ! Factor for protection to use in vertical direction
2.00      15.00      ! from and to z level for protection
   3 !Number of pair values
   0.0000    0.0000
   0.5000    0.0000
   1.0000    0.0050
0.60       ! Factor for protection to use in vertical direction
   4   2   7   10   19     ! Number of surfaces and each surface category code coupled to this protection
CalculatedOpenTerraint'        ! User description
'F:\A60\IndirectFire\common\calculated open terrain.cmp' ! Path to calculated map protection file
   4   4   5   6   17        ! Number of surfaces and each surface category code coupled to this protection
```

Figure 10 Example of an environment protection file.

2.3 Creating calculated map protection file

The map protection file is created from a scene similar to the direct fire scene and contains a plane ground and a number of different ground objects. Each ground object is described in the same way as a target but includes only structure components and a material file.

2.3.1 Assembling a scene

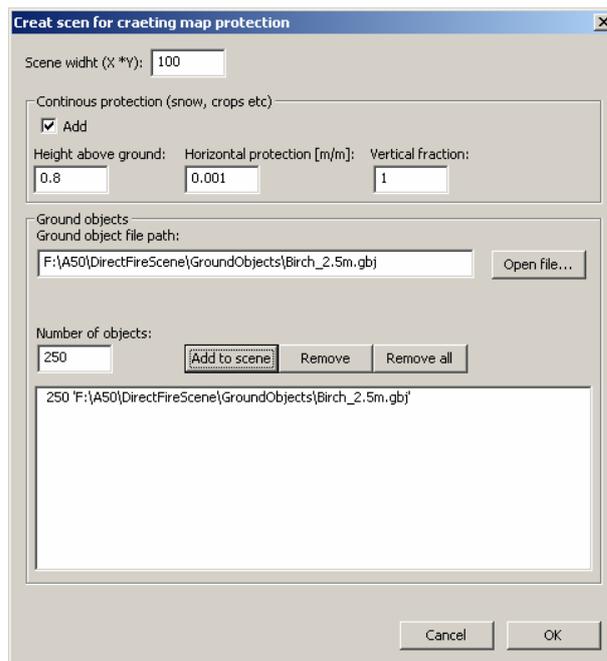Via **Protection->Create new** in the menu opens the dialog to assemble a scene.

Figure 11 Create scen for creating map protection dialog box.

Continuous protection

If this option is checked values for continuous protection can be added. For a given height above the ground level a continuous horizontal protection, given as penetrated m steel per traveling meter, and the corresponding fraction of vertical protection can be added. Can describe for instance snow or crops.

If continuous protection is defined it will be added to protection determined by hits in objects.

Objects

Open object files, add the number of wanted instances and click **Add to scene** to assemble the scene.

When the dialog is closed with OK all instances are added to the scene and the position and bearing is randomized for each instance. This can be re-randomized at any time by selecting **Protection scene ->Randomize new positions** in the menu.
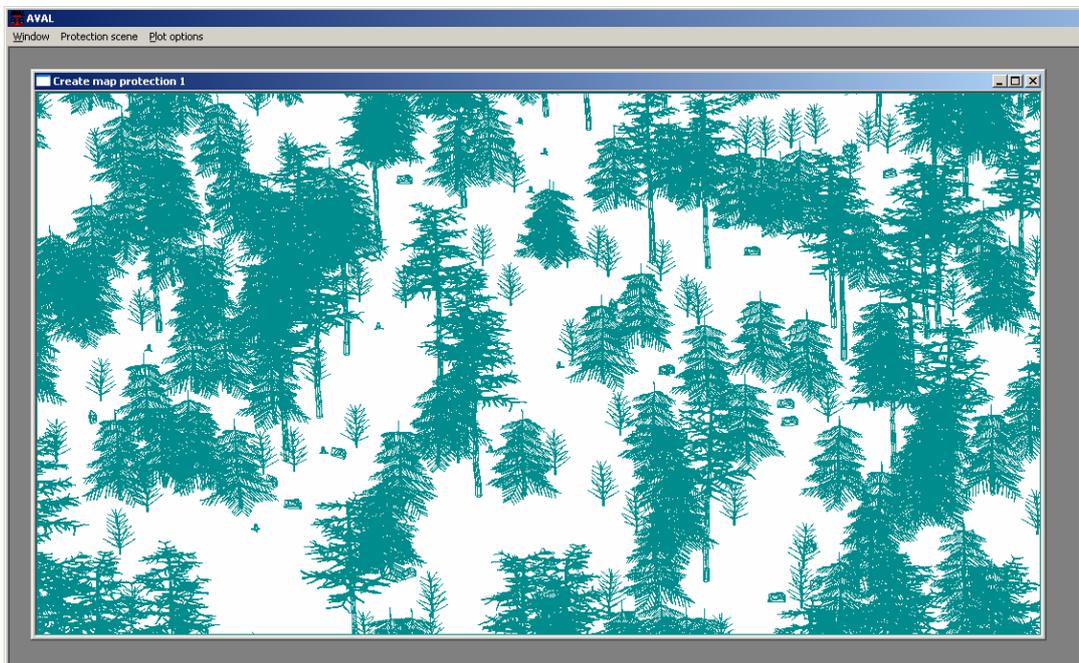

Figure 12 Example of objects randomized in the scene.

2.3.2   Calculating protection

The map protection file is calculated and saved via **Protection scene -> Calculate** in the menu.
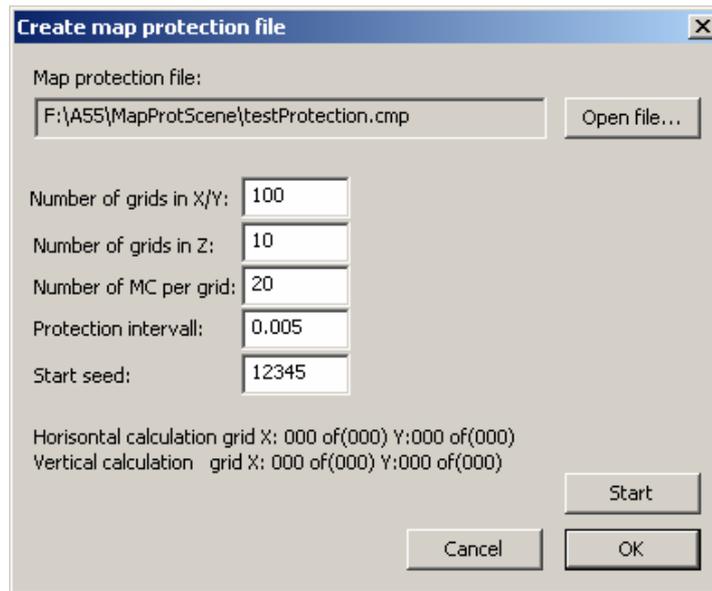
Figure 13 Create map protection file dialog box.

The protection file is created by performing horizontal and vertical ray tracings through the scene and saving number of hits into the selected file. All hits are divided into protection classes by using the given protection interval. If the interval is set to 0.0005 m all hits in components with protection 0 – 5mm will be added into protection class 0 and hit with protection 10-15mm in protection class 2 etc. Number of grids in X/Y is used to distribute the MC simulations evenly in the scene and selected number of grids in Z will be the number of Z-levels used in the simulation. There is no restriction in number of Z-levels as is for the protection type 1.

For each ray tracing the number of hit components are counted and the protection for each hit is the sum of the protection in the going in surface, internal protection and going out surface.

In the example above the protection is increased 0.005 m for each protection class and when a ray tracing gets 10 hits, through the 10m wide scene, they are distributed with 4 times in protection class 0, 1 in class 2 , 2 in class 3, 3 in class 4 etc. with a total of 20 hits. I.e. two rays out of the 500 have hit 10 structure components.

A table as described above is save for horizontal and vertical protection in each set Z-level where z-level is given from the number of grids set before calculation.

2.4 Calculating environment protection in simulations

2.4.1 General

For fragmenting warheads a ballistic calculation is performed for each fragment. In addition to air drag the environment protection, depending on fragment position and height over ground, is reducing the fragment velocity. The environment protection is considered in each iteration step during the ballistic calculation and decreases the fragment velocity.

2.4.2   Calculation of environment protection for method 1

The following description uses the environment protection data in the bold text in the *.evp* file.

```
'Forrest'        ! User description
   3         ! Number of levels with various protection
0.00        0.50        ! from and to z level for protection
   3 ! Number of pair values
   0.0000      0.0000
   0.5000      0.0000
   1.0000      0.0100
0.10        ! Factor for protection to use in vertical direction
0.50        2.00        ! from and to z level for protection
   3 ! Number of pair values
   0.0000      0.0000
   0.8000      0.0100
   1.0000      0.0100
0.30        ! Factor for protection to use in vertical direction
2.00        15.00       ! from and to z level for protection
   3 ! Number of pair values
   0.0000      0.0000
   0.5000      0.0000
   1.0000      0.0050
0.60        ! Factor for protection to use in vertical direction
```

Figure 14 Example of .evp file

For each iteration in the ballistic calculation of the fragment the environment protection in the map is randomized using the current height of the fragment. The used height is the mean value of the start and end position of the fragment in current iteration step. If the height of the fragment is 1.5 m above the ground the second protection curve the example is used.
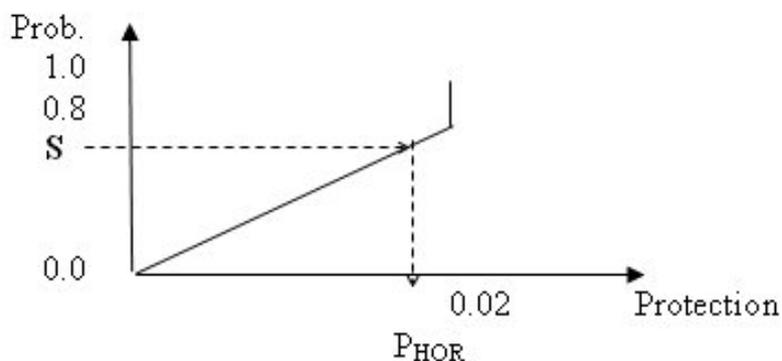

Figure 15 Protection probability description.

A number, $S = [\,0,1]$, is randomized and used to determine the horizontal protection P_{HOR}.

The vertical protection is in this case:

$$P_{VERT} = 0.3 \cdot P_{HOR}$$

The total environment protection of the fragment is given from:

$$D_{HOR} = \sqrt{(x_{end} - x_{start})^2 + (y_{end} - y_{start})^2}$$

$$D_{VERT} = \left| z_{end} - z_{end} \right|$$

$$P_{TOT} = P_{HOR} \cdot D_{HOR} + P_{VERT} \cdot D_{VERT}$$

The fragment penetration capacity before the environment protection is calculated as:

$$G = G_0 \cdot \left(\frac{m}{m_0}\right)^a \cdot \left(\frac{v}{v_0}\right)^b$$

The reduced penetration capacity is

$$G_{RED} = G - P_{TOT}$$

The reduced penetration capacity, G_{RED}, is used to calculate a new reduced velocity, v_{RED}

$$v_{RED} = \left(\frac{G_{RED}}{G_0} \cdot \left(\frac{m}{m_0}\right)^{-a} \right)^{\frac{1}{b}} \cdot v_0$$

2.4.3   Calculation of environment protection for method 2

The protection method 2 have calculated protection both horizontally and vertically for each z-level. The midpoint of the fragment position in current iteration step determines which level to use.

Protection is randomized with number of hits, protection of each hit and distance to each hit within a length of given scene width, for horizontal protection, or height of current z-level, for vertical protection, which is equal to length of ray tracing. New protection is randomized once for each new fragment and when the horizontal position of current fragment exceeds the length of the ray, i.e. the scene width.

The example below shows the counted hits for horizontal ray tracing through the scene in z-level 1 from 0 to 1.148 m above the ground.

```
!*** ******* ****** ******* ****** ******* ****
! Z - level 1 - Horisontal protection
!*** ******* ****** ******* ****** ******* ****
!  Fom Z:     To Z:
    0.000    1.148
    500              !Total number of horisontal rays in this level
!Table with number of rays with nSurface hits in each protection interval
!Protection
!interval:
!        nSurface hits:   (Length of each ray = 10.0000 [m] )
          1   2   3   4   5   6   7   8   9  10  11  12  13  14
    0     4   9  11   5   9   7  13   6   0   4
    1     2  12  13  12   9   8   9   4
    2    11  10  18  25  18   8  16   6   3   1
    3     5  14  20  33  22  13  10   6   2   2
    4     5  15  36  16  20  14  15   3   3   3
    5     6  10  25  15  14  13   9   4   3   3
    6     1  12   6  14   6   4   4   1   4   2
    8     1   1   6   4   4   3   4   3   0   1
    0  ! End of hit data
```

Figure 16 Example of horizontal protection

We can see in the table that for rays horizontally through the scene where one surface is hit the protection distribution is 4 times in protection class 0 (0-0.005 m), 2 times in class 1 , 11 times in class 2 etc., with a total of 35 hits.

I.e. 35 out of 500 ray tracings have hit one surface.

The distribution for the case with two hits is described in the next column with a total of 84 surface hits, i.e 84 / 2 = 42 out of 500 ray tracings have hit two surfaces.

The probability of getting N number of hits, P(N), is determined by:

$$P(N) = \frac{\sum_{class} Hits_{class}}{N \cdot Rays}$$

And the probability of no hit at all, not given in the table, is:

$$P(0) = 1.0 - \sum_{N} P(N)$$

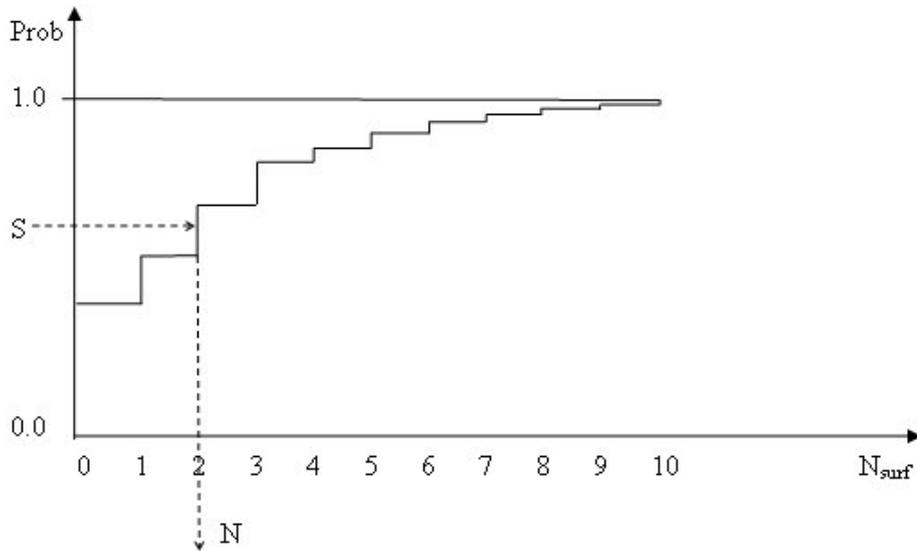To determine number of hits in a randomized ray through the scene a number S = [0,1] is randomized.

Figure 17 Decision of number of hits in a scene.

To establish the protection distribution among the randomized number of hits, N, the protection distribution for N hits in the table is used to determine the probability of each class.

$$P(class) = \frac{Hits_{class}}{\sum_{class} Hits_{class}}$$

Where $Hits_{class}$ is the number of hits in each protection class from the column with N number of hits.

For each surface, 1-N, a number $S_i = [0,1]$ is randomized and used to determine the protection of the hit surface.
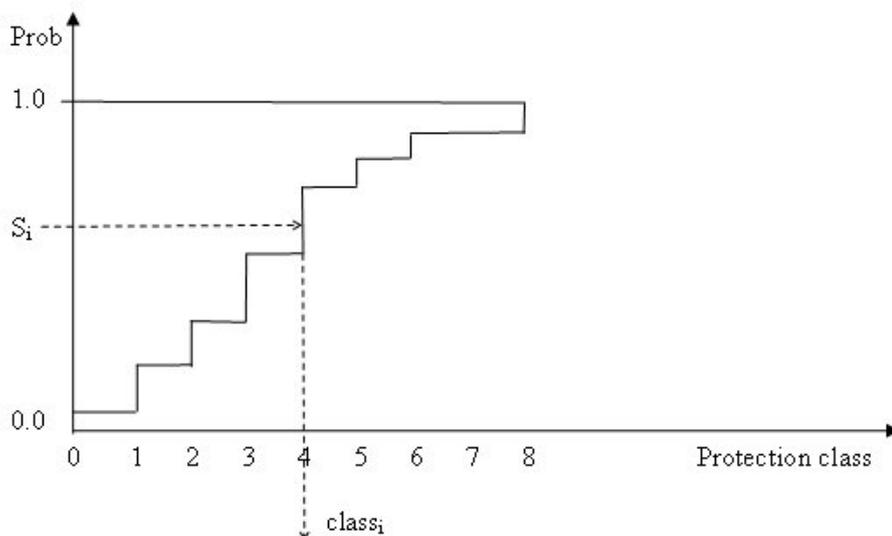

Figure 18 Decision of protection class in a scene.

The protection of hit i is randomized within the given protection class. In the example above the randomized protection class is 4 and the protection interval, given above tables, is 0.005 m whereas the protection for hit i will be:

$Prot_i =]0.020, 0.025]$

$Prot_i$ is randomized with rectangular distribution.

The distance to each hit will be randomized within the scene width (equal to length of ray trace) with rectangular distribution, or within each z-level for vertical protection.

2.5 Calculating environment protection in simulations

2.5.1 General

For fragmenting warheads a 3DOF mass point ballistic calculation is performed for each fragment including air drag. The environment protection is considered in each iteration step during the ballistic calculation. The result is depending on fragment position and height over ground and reduces the fragment velocity.

2.5.2 Calculation of environment protection

The following description uses the environment protection data in the bold text in the *.evp* file.

```
'Forrest'        ! User description
    3        ! Number of levels with various protection
0.00        0.50        ! from and to z level for protection
    3 !Number of pair values
    0.0000        0.0000
    0.5000        0.0000
    1.0000        0.0100
0.10        ! Factor for protection to use in vertical direction
0.50        2.00        ! from and to z level for protection
    3 !Number of pair values
    0.0000        0.0000
    0.8000        0.0100
    1.0000        0.0100
0.30        ! Factor for protection to use in vertical direction
2.00        15.00        ! from and to z level for protection
    3 !Number of pair values
    0.0000        0.0000
    0.5000        0.0000
    1.0000        0.0050
0.60        ! Factor for protection to use in vertical direction
```

Figure 19 Example of an .evp file.

The environment protection in each iteration in the ballistic calculation for the fragment is randomized using the current height of the fragment. The used fragment height is the mean

value of the start and end position of the fragment in current iteration step. For a height of the fragment of 1.5 m above the ground the second protection curve the example is used.
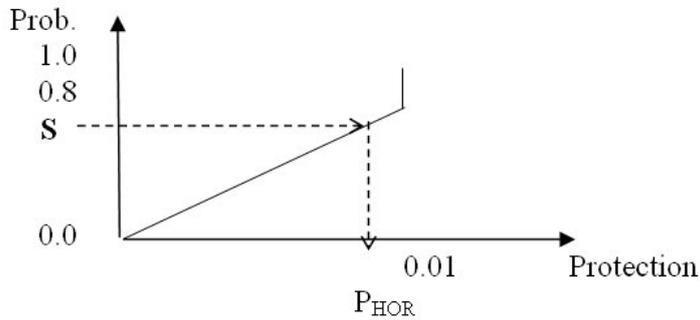

Figure 20 Protection probability description.

A number, S = [0,1], is randomized and used to determine the horizontal protection P_{HOR}. The vertical protection is in this case:

$$P_{VERT} = 0.3 \cdot P_{HOR}$$

The total environment protection of the fragment is given from:

$$D_{HOR} = \sqrt{(x_{end} - x_{start})^2 + (y_{end} - y_{start})^2}$$

$$D_{VERT} = \left| z_{end} - z_{end} \right|$$

$$P_{TOT} = P_{HOR} \cdot D_{HOR} + P_{VERT} \cdot D_{VERT}$$

The fragment penetration capacity before the environment protection is calculated as:

$$G = G_0 \cdot \left(\frac{m}{m_0} \right)^a \cdot \left(\frac{v}{v_0} \right)^b$$

The reduced penetration capacity is

$$G_{RED} = G - P_{TOT}$$

The reduced penetration capacity, G_{RED}, is used to calculate a new reduced velocity, v_{RED}

$$v_{RED} = \left(\frac{G_{RED}}{G_0} \cdot \left(\frac{m}{m_0} \right)^{-a} \right)^{\frac{1}{b}} \cdot v_0$$

$$v_{RED} = \left(\frac{G_{RED}}{G_0} \cdot \left(\frac{m}{m_0} \right)^{-a} \right)^{\frac{1}{b}} \cdot v_0$$

3 Map tools

The following commands are available in the Map tools menu:

Zoom in Select **Map tools -> Zoom in** the menu and left click in the map or select **Map tools -> Zoom window** and draw a window to zoom in.

Zoom out Select **Map tools -> Zoom out** in the menu and right click in the window.

Zooming in and out is also possible with a mouse wheel.

Pan Drag the map in the window with the mouse and the right mouse button down.

Under **Map tool**s in the menu following functions are also available for the scene.

(Note that some commands will be active until it is inactivated or a new command is chosen.)

View coordinates

Opens a dialog to show coordinates and terrain category at the mouse position. These values are also displayed at the bottom of the map window.

Figure 21 Map coordinates dialog box.

Show height database extension

Draws a frame around loaded height databases. The height at current mouse position is displayed at the bottom of the map window and indicates if a height database is loaded.

Show separate round aim points (Only in Indirect fire mode)

If a weapon platform has separate aim points for each round this command will show the aim point of each round in the weapon platform if activated.

Show targets in real scale

This option will draw the target by its extension in real scale and with selected bearing in the scene.

Figure 22 Target in real scale and direction in scene.

Figure 23 Target symbol in scene.

Show mine positions (Only in Minefield mode)

To show randomized positions of all mines in all minefields. Since randomized new positions will be shown each time the command is activated.

Show target paths

Command to show or hide defined target paths. Target paths will be used in simulation regardless if they are showed or not.

Symbol text height

Command to resize symbol text.

Show symbol text

Command to show or hide symbol text.

Scale bar

If activated, a scale bare is showed in the lower left corner of map.

Ruler

Measures distance and bearing from last mouse click to current mouse position. Adds distances between all mouse clicks until reset with the **Clear** button.

Figure 24 Ruler dialog box.

Lock targets, weapons and **hit points**

Locks chosen symbol type to avoid unintentionally moving of these symbols with the mouse.

Multiple move

Enables window selection to select and move multiple targets in the scene without changing their relative positioning. Select objects by left clicking in one corner and release the mouse button in the opposite corner of the selection window. Set a new position by left clicking in the map. The insertion point will by default be the center point of all selected objects.
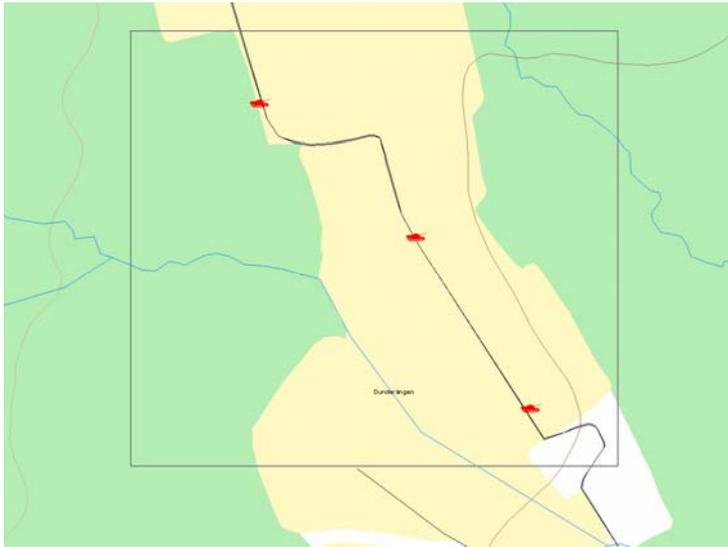
Figure 25 Example of map with locked objects.

Locked object types will not be moved.

Move object

Command to move a single object in the map. Select objects by left clicking on the object, move the object with the mouse button kept down and release the mouse button at the new position.

Edit object

Command to edit inserted targets, target paths, weapons, observer or mine fields. Left klick on the object to edit and the same dialog used when creating the object will be opened.

Copy object

Used to create a new instance of an existing object in the scene. The new object will get the same input data as the original except for the position. To separate weapon hit points the copy of a weapon platform will get a hit point 100 m north east of hit point of the original weapon platform.

Change Map

This option will switch the map in the window between the original bitmap image and the calculated terrain map with only colors for defined terrain types.

If no terrain map is loaded nothing is viewed and the window will be all white.