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Multiparameter Numerical Medium for Seismic Modelling, Planning, Imaging & Interpretation QC Worldwide

TESSERAL GEO MODELING SUITE

Windows Workplace (Pro V5.1.4)

User's Manual

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1 About Tesseral Pro

Tesseral Pro is designed for calculating seismic synthetic gathers using finite-difference wave equation approximations, such as acoustic, elastic, anisotropic, visco-elastic and 2D ray-tracing (approximation by eikonal equation). In the Tesseral Pro, the depth velocity models can be built from well data, geological surface maps or 2D/3D grids.

Also Tesseral Pro allows building a 3D observation system and performing 3D Ray tracing.

1.1 Tesseral Pro package download and Installation

The latest versions of the Tesseral products can be downloaded from the following links: <u>http://www.tesseral-geo.com/download.en.php</u>

To start the installation process, please unzip the file and then run the setup executable.

NOTE: If you have purchased the Tesseral Pro USB-key license, please do not insert your USB key before finishing the installation. The drivers for USB key will be set up during the installation.

After successful installation, a Welcome dialog (below) will appear.



In the <u>User Information</u> dialogue box you may enter your name and specify if other users can use Tesseral Pro on this computer (the current user only or all the users of this computer).

🗒 Tesseral Pro Setup		
User Information Enter the following info	rmation to personalize your installation.	<u>e</u>
Full N <u>a</u> me:	John Smith	_
Organization:		
The settings for this share this computer, users. Install this apj	application can be installed for the current user or fo You must have administrator rights to install the setti blication for: <u>Anyone who uses this computer</u> Only for <u>m</u> e (Quadro)	all users that ngs for all
	< <u>₿</u> ack Next >	Cancel

After installing Tesseral Pro, just click "Tesseral Pro" in the start menu to start Tesseral Pro:



When Tesseral Pro is started for the first time, you need to enter your registration information or insert your USB key (see Licensing Policy at Section 18). After registration, the program is ready for use.

	Outgoing Code:	<u></u>	
		Please email this outgoing code to Service, and then enter the incor receive.	o the Customer ning key you
	Incoming Key:	W2H9KT71MX4M497MUSXNH	AX6C6
		Please, visit http://www.tesseral- information of how to obtain trial e	geo.com for evaluation key.
		Register	Cancel
HASP	key	Network HASP key	
		Network Address	

Without a license, in the demo mode, the functions of synthetic gathers modeling and gathers processing are unavailable for the users.

1.2 System Requirements

Minimum	Recommended
Windows XP/Vista/7/8/10	Windows XP/Vista/7/8/10
1.6 GHz CPU	2.3 GHz CPU
512 MB RAM	1 GB RAM
400 MB free space on HDD	2 GB free space on HDD
	Network Card (access corporate
	database)

2 Introduction

After launching the Tesseral Pro, a <u>Welcome</u> dialogue box with several options appears.



• The <u>CREATE NEW MODEL</u> button launches the Wizard to create a new model (Section 3.1).

• The <u>LOAD MODEL</u> button is for loading a model in TAM format used in the Tesseral 2D program, WGC format, GXII format or loading a model from a text file in various formats (Section 3.1.9).

• The <u>LOAD SEISMIC FILE</u> button enables the visualization of gathers in standard SEG-Y, internal TGR and SDS-PC formats (Section 13.1).

• The <u>OPEN PROJECT</u> and <u>OPEN LAST PROJECT</u> buttons are for loading the files of Tesseral Pro projects.

If you click <u>Done</u>, the standard empty window of the Tesseral Pro project will appear.

2.1 Layout of Tesseral Pro window



In the left panel the database tree (please see description in the Section 17) and the project tree (please see details in the Section 11.8) are displayed. The right panel is for building the model and visualizing gathers, maps or 3D images. All the objects in the right pane are displayed in rectangular frames (please see details in the Section 11).

At the bottom of the main Tesseral Pro window is the Modelling Wizard, which initiates one of the 3 main steps in a modeling process (Section 2.3).

2.2 Menu overview

• Menu <u>File</u> consists of the options for creating, saving or importing a project (TPA format), loading models, gathers or surfaces, printing document and exporting the project into standard raster-type or vector formats.

• Menu <u>Database</u> is for managing the database in Tesseral Pro, such as creating/selecting database, or importing/editing a well log data (see Section 17).

- Menu Edit is for manipulating Frames.
- Menu <u>View</u> is for general commands for working with Frames.

• Menu Model is for creating and modifying velocity models and acquisition geometry (Section 12).

• Menu Map is for creating/loading a surface map and different ways of displaying the surface map (Section 14).

• Menu <u>Seismic</u> is for loading seismic gathers in SEG-Y, SDS-PC or TGR formats (Section 13) and changing the visualization modes.

• Menu <u>3D View</u> is for viewing 3D images (Section 15).

• Menu Run is for launching computation of synthetic gathers for one particular model or to process these synthetic gathers using available processing modules such as stacking and 2D migration (Section 5, 11).

2.3 General steps for synthetic modeling

At the bottom of the Tesseral Pro window, the 3 sequential steps for creating synthetic gathers are shown:

STEP 1. Creation of the 2D velocity model. The velocity model can be created by using well data, maps of horizons or 2D/3D layered model (SEG-Y format) or LAS file). 1D/2D vector models in various formats from other packages are also supported (Section 3.1).

STEP 2. Creation of the acquisition geometry (source and receiver distribution, section

STEP 3. Set-up of the modeling parameters and start a modeling job which launches one of the following computational engines (Section 5):

- 1. 2D/3DVertical Incidence
- 2. 2D Scalar

4)

- 3. 2D/3D Acoustic
- 4. Acoustic without multiples
- 5. 2D/3D Elastic
- 6. 2D/3D Elastic Anisotropic
- 7. 2D/3D Visco-Elastic
- 8. 2D Eikonal Ray Tracing
- 9. 2.5D Elastic
- 10. 2.5D Elastic Anisotropic
- 11. Haskell–Thomson

The procedures for processing gathers (Section 11) and the module for ray tracing (Section 6) are integrated into Tesseral Pro.

3 Depth model building

To create a depth-domain velocity model in Tesseral Pro, a Model Frame is to be used.

All the objects in the Tesseral Pro are comprised in Frames; see Section 11 for details related to different types and options for manipulating frames.

In the <u>Model</u> Frame users can build arbitrarily complex velocity models for any geological structure, add anisotropic or fracturing parameters into the background model and design the acquisition geometry. The geological model is built by overlapping a set of polygons. Within each polygon, the rock physical parameters could be homogeneous or complicated (with a linear gradient along depth). For model creation, users can use the reflection horizons, velocity, density, anisotropy and other parameters from acoustic well logging, grids of layer data in SEG-Y format, as well as 1D/2D vector models from other packages.

3.1 Building a new model

The first stage of model building is to specify the basic parameters: size of the model (width and depth), geographical reference of the coordinates, and the main source of data used for building models (grids in SEG-Y format, grids or isolines of reflection maps, well data, underlying image and etc). The menu $\underline{Model} > \underline{Create Velocity Model}$ (New Frame) is used. After that, the Wizard for new model creation will appear.

Create new Model
WIZARD
SIMPLE model >
From SEISMIC file >
From SURFACES >
From database WELLS >
From LAS-file >
From SPS-file >
From Picture >
Load model from other format file
Manual setting (using Properties dialog)
[[Cance]]

In this dialogue box, users can select one of the main data sources for creation of a depth model. In the next chapters, various options for model building will be described one by one.

3.1.1 Creation of a simple 2D model

Firstly, click the menu <u>Model > Create Velocity Model (New Frame)</u>. Then, select <u>SIMPLE model > in the Create new Model</u> pop-up dialogue box.

In the <u>Section</u> dialogue box, specify the model's length and the top and bottom of the depth model.

NOTE: The distance units in the model may be meters or feet. Select the measurement units in the project as described in the Section *16*.

Section	X
	Model
len 0 200 400	0 600 800
400	400
	_ Depth
Length 1000 m	Top 0 m
	Bottom 1000 m
< <u>B</u> ack	Next > Cancel Help

After specifying model's size, click <u>Next</u>. You will see the <u>Base Polygon</u> dialogue box where the constant or linearly-increasing compressional velocity of the background model (base of the other polygons) can be specified.

		Mos	del			
200	00	2	500		3000	
len O	200	400	600	800		
					F 1	
· -					+ 1	
400					400	
-						
• •					- 1	
800					800	
•	المعامية الم	2000		- /-		
	ar velocity	12000	· · · · · ·	11/3		
 Vertical li 	near velocity <u>o</u>	gradient	(V=A+Depth	*B)		
V = 18	00	+ Depth	• 1.32			

After clicking <u>Finish</u>, the Frame Model will be created, and you will be asked to design the acquisition geometry used for modeling, as shown below:

Acquisition Geometry	X
Do you want to run "Ad	cquisition Geometry WIZARD"?
	<u>Y</u> es <u>N</u> o

This message will always pop up after creating a new model. Please see more details about designing related source/receiver distribution in the Section 4.

After the "empty" Frame Model is created, it has to be overlapped with polygons with various velocities, density and other rock physical parameters. Please see more details about how to build a model using polygons in Section 5.

3.1.2 Creation of a model from a SEISMIC file

If you have a 2D or 3D velocity depth model in SEG-Y format, you can use it as an underlying image for the model.

For example:



This means that, instead of drawing polygons and adjusting their parameters, users have the option of using SEG-Y files directly. Users only need to select the size and location of the model. If the SEG-Y files contain only compressional velocity, then the other parameters (shear velocity, density) will be calculated automatically by using some empirical formulae. Importing density, shear velocity and anisotropy from SEG-Y files is also supported.

The time-domain model in SEG-Y format may also be used. But it needs to be transformed into depth model in advance; the <u>Run > Velocity Model > Time to Depth</u> <u>Transformation</u> menu is used for this purpose. Please see more details in the Section 10.2.2.

```
NOTE: In Tesseral Pro, SEG-Y files can be visualized by using the menu <u>Seismic ></u>
Load Seismic File (New Frame) (please see the Section 13 for details)
```

After clicking the <u>Model > Create Velocity Model (New Frame)</u> menu, you will see the <u>Create new Model</u> dialogue box. Then click the <u>From SEISMIC</u> file > button to build the model from the seismic file.

STEP 1. Selection of a SEG-Y file with velocities

In the \underline{File} dialogue, please select the 2D or 3D seismic file in one of the SEG-Y or TGR formats.



Apart from the compressional velocity data, you may also have depth-domain seismic files with density, shear-wave velocity or anisotropy data. These files may be also used as the underlying image for the corresponding components. Click the <u>Add other component</u> <u>files</u> button to select the files of other components in the <u>Model from seismic files</u> pop-up dialogue box.

Nodel from Seismic File	5		×
Compressional Velocity	sseralPro\Tesseral 3D Files\DUPLEX_VELOCITY_MODEL.sgy	Load	Remove
Density	FesseralPro\Tesseral 3D Files\DUPLEX_DENSITY_MODEL.sgy	Load	Remove
Shear Velocity)fTesseralPro\Tesseral 3D Files\DUPLEX_SHEAR_MODEL.sgy	Load	Remove
Anisotropy Epsilon		Load	Remove
Anisotropy Delta		Load	Remove
Anisotropy Phi		Load	Remove
	ОК		Cancel

When the seismic file is selected, press the Next > button.

STEP 2. Selection of coordinates and the Model profile

In the next dialogue box <u>Profile</u>, if the seismic file is 3D, users need to enter the coordinates of the model profile, or draw the profile manually in the plan by pressing-dragging and releasing the left mouse button.



STEP 3. Size of the model

In the next dialogue box <u>Section</u>, please specify the top and the bottom of the model:



The model with the underlying seismic file is ready. Then, the users will be asked to design an acquisition geometry for the model (please see the Section 4 for details).

Users may add polygons above the underlying image to finalize the model building. In Section 3.1.8, see details about how to adjust the model's parameters, which have an underlying

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SEG-Y image.

3.1.3 Creation of a model from Maps

The grids or isolines of the reflection horizons may be used for the automatic creation of model's polygons. In this case, the 2D model is built as a vertical section in the 3D cube of surfaces (see figure below). As a result, the top and the bottom of each polygon have the same shape as the surfaces for the given section.



To use this function, first click <u>Model > Create Velocity Model (New</u> <u>Frame</u>), and then in the dialogue box <u>Create new Model</u> click the button <u>From</u> Mapsmaps >.

In the opened dialogue box <u>Maps</u> click the button <u>Add</u> File \geq if a surface is going to be loaded from the file into the Tesseral Pro project (see figure below).



After you have selected the files with surfaces, the dialogue box <u>Choose mapping</u> <u>method</u> will appear, and then the dialogue box <u>Calculate Isolines</u> will appear for adjusting the parameters of the isoline image. Repeat these steps to add more layers. When all the needed surfaces are loaded, press the button Next >.

```
NOTE: You may select several surfaces at a time in the Add File >.
```

In Tesseral Pro, the surfaces may be loaded directly from files that have major text formats, or may be calculated from stratigraphic well data. Please see Section 17 about loading stratigraphic data into the database. Section 14.2 describes the functions for computing surfaces from well data.

In the next dialogue box <u>Profile</u> please specify the profile coordinates manually or draw the profile using the mouse (press-drag-release).



In the figure above, the <u>Max. no. of nodes on profile</u> parameter determines the number of nodes at the top and bottom of each polygon created from the surfaces. Press the button Next > to navigate to the dialogue box Section.



In the dialogue box $\underline{\texttt{Section}}$ please specify the range of the model. In this dialogue © 2019-2021

box, the lines of the polygons are shown. By default, velocities and other parameters of the polygons are not present, so the polygons are displayed in grey color. To specify the parameters for each polygon, select it by mouse and then click <u>Model > Edit Polygon</u> (Section 3.2.5).

3.1.4 Creation of a model from WELLS

The well data (acoustic logging and/or density logging) are mainly used for creation of thin-layered models.

NOTE: To create a model by using well data, the following data need to be loaded into the database:

1) Coordinates of the wells;

2) Survey directionality (if the survey has no directionality, vertical wells with provided altitudes is sufficient);

3) Depths of layer intersections;

4) Acoustic (density) logging data for creating thin-layer models.

Please see Section 17.5 for more details. If users wish to create a simple horizontallylayered model from one LAS-file which ignores the directionality of the survey data, please see the next Section 3.1.5.

Steps for creating a model from the well data:

1. Click Model > Create Velocity Model (New Frame).

2. In the dialogue box <u>Create new Model</u>, click the button <u>From database</u>

WELLS >.

3. In the dialogue box <u>Select Wells</u>, select the wells to be loaded from the list

of <u>Wells</u>. You may mark one or several Fields, and then in the box <u>Wells</u> only wells from these Fields will be shown.

Select Wells	×
Field	
[65535] General (m) [65535] Gorobcivskoje (ft)	
) 	
weils	,
11 12	
6 8	
9	
	Cancel

After selecting the wells, press button \underline{OK} and go to the dialogue box \underline{Wells} .

In the dialogue box <u>Wells</u>, the geographical location of the selected wells is shown, and you may add or remove wells from the profile using the buttons <u>Add</u> \geq and <u>Delete</u> \leq .



When all the needed wells are loaded into the model, press the button $\underline{Next} >$. In the next dialogue box $\underline{Profile}$, specify the coordinates of the model's profile or draw the profile manually by using mouse (press-drag-release):



In the next dialogue box <u>Section</u> please set the top and the bottom of the model:

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In the next dialogue box $\underline{\texttt{Base Polygon}},$ please specify the velocity of the basic polygon:



In the next dialogue box <u>Well data</u>, you may select the stratigraphic arrangements and the logging data will be shown near the wells.

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Check <u>Layers</u> for automatic creation of polygons by stratigraphic correspondences. Check <u>Log</u> for automatically filling the polygons with the parameters from well logging (creation of thin-layered model).

Preparation for creating a thin-layered model

The preparation includes selecting curves for the model and adjusting the re-calculation parameters and the well logging data to characterize the polygons (velocity, density, fracturing, anisotropy).

NOTE: If $\underline{\text{Log}}$ is checked, then the acoustic logging curves will appear to the right of the well, and the parameters for re-calculating these curves are set automatically. If the logging curves do not appear, it is recommended to go to the dialogue box $\underline{\text{Log}}$ by clicking the corresponding button Properties.

In the dialogue <u>Log</u>, please select the acoustic logging curves (DT or acoustic logging) from the list of the curves for the model's wells. For further filling-in of the polygon parameters from the logging data, for the selected curves, please set <u>Specification</u> to <u>Compressional Velocity or dT</u> and also <u>Measure unit to usec/m</u> in order to recalculate the parameters of the polygons from the curves' values correctly.

Log 1. Add logging curve	s	
to the wells	- Well-logs	
Add Well-logs >	Log description	
Delete Well-log <	Net	
Delete All Well-logs <<	Set the type of the surger is the selected in	
a	nd the measurement units	
DT	Scale _	
Specification Compression	Velocity or dT Measurement unit usec/m	
From	To Cosla	
	452 (unit/mm) Top 7874.02 ft	
1 0	452 45.2 Bottom 13399 ft	
2 0		
3 0		
Scale type	Linear	
Line style 🔽 Scale at	utocalculation By default	
Coloob) (folloo D	inden) (all les informatio	
3. Set the scale and the lines for the curve Cancel		
L		

Then press OK and the Log dialogue box will close. As the result, in the <u>Well data</u> dialogue, the logging curves should appear near the wells. Press the <u>Next</u> > button to go to the next dialogue box <u>Add polygons</u>.



In the dialogue box <u>Add Polygons</u>, from the drop-down list <u>Create Polygons</u> from Layers, the following options are available for the creation of polygons:

© 2019-2021 Tesseral Technologies -*User Documentation*- • No – do not create the polygons automatically

• <u>All layers</u> – to create the polygons for all the layers which exist *at least in one* of the selected wells. It means that, if the layer exists in any of the selected wells, it will be used for the creation of polygons.

• <u>For all wells</u> – create polygons for the layers which exist in *all the selected* wells. As a special case, if a layer is not present at least in one of the selected wells, it will not be used for creation of polygons.

• Selected – select the layers manually from the list of the layers in the database.

Check <u>Create Polygons from Horizon</u> to create the polygons using the previously loaded surfaces. In this dialogue box, users can load the surfaces by clicking the button Load.

As a result, the model will be created in which the velocities (and/or) other parameters will be obtained automatically from well logging data. However, as mentioned above, users need to load in advance the databases: coordinates of the wells, coordinates of layers' intersections and the logging curves (please see the Section 17.5 for more details).

The parameters interpolated by logging data (thin-layering) are not shown in the polygons. The interpolation is done automatically before the modeling job is launched. You may QC the quality of the final model by using $\underline{Model} > \underline{Export}$ to $\underline{Seismic}$ Format (SEG-Y, TGR menu item to export the velocity model to a grid file.



NOTE: This grid file is not used in actual calculations. It is used only for QC/visualizing the final model to be used in modeling.

In the Tesseral Pro, some special tools are implemented for creating and adjusting polygons whose properties are derived from well data. Please see Section 3.2.9 for more details. By building polygons from well data, thin-layer models are created.

3.1.5 Creation of a simple flat layered model from LAS file

In this section, a simple method is described for creating a model from acoustic logging data and/or density measurement data without loading the data in advance into database.



To start this functionality, first click <u>Model > Create Velocity Model</u> (New <u>Frame</u>), then in the dialogue box <u>Create new Model</u> click the button <u>From LAS-file</u> <u>></u>. In the dialogue box <u>LAS-file</u>, select the LAS-file containing the velocity and/or density.

LAS-file				×
LAS file	C:\Sheldon\Testin	gOfTesseralPro\SonicOnly	r.las	
, and here a				Elevation 694.29998; m LAS Top 360 m
, A				2303 m
Compress	sion Velocity or dT	DT	•	us/m ?
Density		-Not specified-	•	units ? 🗨
Shear Ve	locity or dT	-Not specified-	•	units ?
	< <u>B</u> ack	Next >	Cancel	Help

In the dialogue box <u>LAS-file</u>, select the curve corresponding to the component of the model <u>Compressional Velocity or dT</u>, <u>Density</u>, <u>Shear Velocity or dT</u>, and then select the units of measurement for each component.

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It is also recommended to set the well altitude (<u>Elevation</u>) correctly. The directionality of log data is not used for creating horizontally-layered models. However, it will not be enough to have only altitudes for conventionally vertical wells.

Section					×
		Model			
len 0	200 4	00 600	800		
1000				1000	
2000				2000	
		Depth			
Length	000 m	Тор	0	m	
		Bottom	3000	m	
	< <u>B</u> ack	Next >	Ca	ancel	Help

In the next dialogue box Section, specify the length and the model's depth range:

Then specify the velocity for the basic polygon.

Base Polygon	×
Model	
len 0 200 400 607	0 800
1000	1000
2000	2000
	<u> </u>
	_
Compressional velocity 2000	m/s
Vertical linear velocity gradient (V=A+D	epth*B)
V = 0 + Depth * 0	
,	
< <u>B</u> ack <u>N</u> ext	t > Cancel Help

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In the last dialogue box <u>Create polygons from LAS-file</u>, specify the parameters which will be used for building a thin-layered model. These parameters determine the number and the thickness of the polygons created automatically from the LAS-file.

<u>Clearance</u> is the maximally allowed velocity variation within a polygon. Min. Sampling rate by Depth is the minimum thickness of a polygon.

		Mode				
2000	3000	4000	50	000	6000	
len 0	200	400	600	800		
					F 7	
1000					1000	
2000					2000	
2000					2000	
Clearar	ice		5	÷ %		
Ma C		Death	10			
Min. Sa	impling rate b	y Depth	110	m		
Preview	v:	Create	polygons			

For models built from well data, the polygons are filled by the interpolated parameters from the wells. If only LAS-file is used for model building, numerous thin polygons are created. To check the quality of the specified parameters, press the button <u>Create polygons</u>. Feel free to play with the parameters if you do not like the results.

3.1.6 Creation of a model from SPS-file

If you want to reproduce a field acquisition geometry while creating synthetic gathers and design the model surface using the real altitudes of sources and receivers, it is recommended to use an SPS-file to create the new model.

NOTE: The SPS-files may be also used only for reproducing the acquisition geometry in a created model. Please see details in the Section 4.7.

To use this feature, click <u>Model > Create Velocity Model (New Frame)</u>. Then, in the dialogue box <u>Create new Model</u> press the button From SPS-file >.

Then in the dialogue box Load SPS files, select the files of sources, receivers and their acquisition geometry.

Also, please note that SPS scripts of all types are supported, as well as SEG scripts, KML (KMZ), and TXT file (with the following simple format: SrcX, SrcY, SrcZ, RcvX, RcvY, RcvZ)

Load SPS files	×
SPS-file type	KML auto detection SPS 1 SPS 2 SEG SP KML TXT
C:\Users\Stefan\Des	sktop\Tesserral Pro testing new version\KML\test Shots.kmz
Receivers F	ile \Tesserral Pro testing new version\KML\test Receivers.kmz
Shot-Receiver Rela	ation File
Use Relation File	
	< Back Next > Cancel Help

After specifying and loading the correct SPS file type, click <u>Next</u> and in the dialogue box <u>Profile</u>, specify the model profile:


In the figure above, the red rectangles indicate the sources, and the blue dots indicate the receivers. Please note that it is only possible to build 2D models in the Tesseral Pro, and so only the sources and the receivers close to the selected profile will be included.

To select the profile coordinates more accurately, please use the button Zoom map.

In the next dialogue box <u>Sources and receivers selection</u>, specify the parameters used for selecting the sources and receivers and binning the selected sources/receivers. This dialogue box is needed for proper extraction of needed sources and receivers from the loaded 3D acquisition geometry.



Then in the next dialogue box <u>Section</u>, specify the depth range of the model and how to use the altitudes of the sources and receivers saved in the SPS-files (the parameter <u>Sources</u> and receivers elevation):

• <u>set SPS elevations</u>: the top of the basic polygon that is to be built by the altitudes of sources and receivers.

• <u>move under model top</u>: the sources and the receivers are moved to the models' top

• <u>ignore</u>: the basic polygon of the model and the altitudes of the sources and the receivers are assigned independently.

Section	x
Model	
len 0 4000 8000	
2000	
Model depth Sources and receivers elevation	
Bottom 3000 m	J
< Back Finish Cancel Help	

As in other model creation methods, users need to fill in the obtained model with polygons (please see details in the Section 5).

3.1.7 Creation of a model from PICTURE

This method is used for drawing model polygons manually from the underlying picture. To use this option, click <u>Model > Create Velocity Model (New Frame)</u>. In the dialogue box Create new Model, press the button From Picture >.

Then in the next dialogue box, select the underlying picture in a BMP, JPEG, TIFF, GEO-TIFF, GEO-JPEG format pictures with coordinates in TFW, JGW files, by clicking the button <u>Property</u>.

File				×
	Ľ	lodel		
len 0	200 400	600	800	
400			400	
Picture				Property
	< <u>B</u> ack	<u>N</u> ext >	Cancel	Help

In the dialogue box <u>Picture for Model</u>, select the file of the picture and the area (part) of the picture, which will be used as an underlying image in the Frame Model.



Then in the next dialogue box $\underline{\texttt{Section}},$ specify the depth range and the length of the model.



After that, the Frame Model with the underlying picture will be created, as shown below.



This underlying picture cannot be used for modeling, but the polygons may be drawn manually by following the visible boundaries, and then velocity and other parameters for the created polygons need to be specified.



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Here is the final result of modeling using raster image.

3.1.8 Hybrid method for model creation

You may create a model by using a SPS file, surfaces, a gather for the velocity model and well data simultaneously. At first, users need to create an initial model using any of the methods. Then choose the model creation command <u>Model > Create Velocity Model (New Frame)</u> again. You will be asked whether you would like to change the existing model or create a new one. Select Yes to use the other model creation method in order to change the model.



3.1.9 Load model in other formats

Use the command <u>Model > Create Velocity Model (New Frame)</u>, and then in the dialogue box <u>Create new Model</u>, click the button <u>Load model from other</u> <u>format file</u>.

The supported formats include TAM (model format from the Tesseral 2D package), WGC, GXII and table text files. Surely, users can also load a model from another project (TPA format).

3.1.10 3D Model building from Maps

Load all surfaces you want to use for 3D model building by going <u>Map > Create</u> Map (New Frame) > Load TXT or GRD- surface files

For instructions on how to load or create surfaces from XYZ text files, please follow the instructions from Section 14

Select the surfaces you want to use as horizons:





You can manage and view all surfaces individually by going <u>Map > Manage/Delete</u> Maps. Next, it is advisable to order <u>Order Horizons</u> by Depth.

Manage maps	with the state		×
CCAT(2)_local.grd DELKPT(3)-local.grd DWABAM(4)-local.grd PRECAMB(1)-local.grd		3200	S.
		Ž	<u> </u>
Properties 3D-Model Properties			3.
Delete Map Deselect Order Horizons by Depth		Display (OK)	Cancel

Once all surfaces have been loaded, values must be introduced for all layers created by these surfaces. In order to do that, a 2D cross-section needs to be generated first. This is done by accessing $\underline{Map} > \underline{Section} \quad \underline{Mode}$ and drawing the profile on the surface, by pressing-dragging-releasing the left mouse button.



In order to see the cross section you need to bring down the (encircled) lower header:



This is done by left clicking on the lower header and then dragging it down with the left mouse button.



To assign a value (i.e. compressional velocity, shear velocity, density etc.) to a particular layer click on Map > Manage/Delete Maps > 3D-model Properties.

3D-Model Properti	es 🛛 🗶
Filling cells UP	CCAT(2)_local.grd*
VALUE	2000
Get values from	n map 🛛 - not used - 💌
Use well log	values
Filling Empty Sel	ls (as default) OK Cancel

Depending on whether you want to fill the upper part or the lower part of the surface, you specify <u>Surface type</u> bottom, or <u>Surface type</u> top respectively.

Repeat this step for all loaded surfaces. Once completed, void (i.e. unfilled) space will remain in the map frame, since all surfaces can be either <u>Type: top</u> or <u>Type: bottom</u> and not both.



Finally to create a 3D SEG-Y file go Run > Map Frame > Create 3D SEG-Y...

Create 3D Seg-Y Mo	del				×
Output seg-y file	3Dcube.	sgy			
	Grid par	ameters			
		Min	Max	Step	Size
	x	40	3950	10	392
	Y	40	4510	10	448
	z	0	3380	10	339
		Set '	"Min" and "Max" f	from Map Frame	
	-Filling Er	npty Cells (a	as default)		
	📃 Filli	ing empty ce	ells from upper ce	ells	
	Base \	value (6000		
	Use ba	ase seismog	ram		
	·	not used -			▼
	Value ra	ange			
	Min	100	M	lax 10000	
		100		10000	
				OK	Cancel

Specify the X, Y, Z dimensions you want for your 3D model, the grid sampling, as well as the <u>Filling cells</u> value with which you want to fill the remaining blank layer(s). Also, specify

the pathway and name of the <u>Output seg-y file</u>, with *.sgy* extension. If you want to fill the remaining blank layer(s) from a base seismogram (i.e. from 3D SGY cube), then load it in the <u>Use base seismogram</u>.



Also, it is possible to fill multiple layers from different base seismograms. In this case these base seismograms are loaded for each surface individually, in the <u>Map > Manage/</u> <u>Delete Maps > 3D-model Properties</u>>Filling Empty cells(as <u>default)>Use base seismogram</u>.

3D-Model Propertie	
Filling cells UP	DELKPT(3)-local.grd 💌 top 💌
VALUE	3000
Get values from	map - not used - 💌
Use well log	values
Filling Empty Cells	(as default)
Filling empty	cells from upper cells
Base value	0
Use base seismo	gram
C:\Users\St	efan \Desktop \DUPLEX_VELOCITY_MODEL_n =
Use well log v	values (for all horizons)
	OK Cancel

Important note: If a single or several base seismograms were used for building a 3D cube, then the user will notice that after clicking OK in the Run > Map Frame > Create 3D SEG-Y, the generated 3D SGY cube will NOT contain the assigned base seismogram. Instead, the 3D seismogram will appear in the map frame for the assigned surface. Below you can see the layer extracted from the 3D base cube appearing in the map frame after the generation of the SGY cube:



Once you repeat $\underline{Run} > \underline{Map} \quad \underline{Frame} > \underline{Create 3D} \quad \underline{SEG-Y}$ the second time, the correct cube will be generated. So you can always use the map frame as QC, before generating the cube.

3.1.11 Introducing vertical gradients in 3D cubes

In addition, the user can also introduce horizontal and vertical gradients to any surfaces. To introduce a vertical gradient assign <u>Map type: Top</u> and <u>Map type: bottom</u> for the upper and lower surfaces respectively, which make up the layer where the gradient is supposed to be introduced. This is done in Map > Manage/Delete Maps > Properties

Once <u>Map type</u> has been defined, assign the gradient value for both: the upper and lower surface (i.e. to the <u>Map type: top</u> and <u>Map type: bottom</u>), in the <u>Map ></u> <u>Manage/ Delete Maps > Properties</u>, which this will produce the vertical gradient.



3.1.12 Introducing horizontal gradients in 3D cubes

A horizontal gradient can only be introduced from surfaces. Such surfaces can be easily created by introducing the X Y V coordinates in a text file (having the .xyz extension). These velocity surfaces are loaded like any other regular surfaces <u>File> Load Map file</u> and should be assigned <u>Map type: Parameter</u> in the <u>Map > Manage/Delete Maps > Properties</u>.

Map properties	X
Name Parameter surface.xyz Map type parameter Value interval Min (depth) 798.801 Max (depth) 6586.9 Clipping Gain (%) 0 OK Cancel	

Afterwards, the horizontal gradient (or the velocity surface) can be assigned to the appropriate surface in the <u>Map > Manage/ Delete Maps > 3D-model Properties</u> \geq <u>Get value from map</u>. Please note that a <u>VALUE</u> must be introduced as well, in case there are any "holes" in the velocity map in places of faulting, wedging or other complex geologic features. If there are no holes in the velocity map, then the specified <u>VALUE</u> will be ignored.

3D-Model Properties			
Filling cells UP	Grid 1.grd	•	top 🔻
VALUE 20	000		
Get values from ma	ap Param	eter surface.xyz	•
Use well log valu	ues		
Filling Empty Sells (a	is default)	ОК	Cancel



3.1.13 Introducing cylindrical bodies and tetrahedrons in 3D SGY cubes

The user can also introduce cylinders and tetrahedrons in any given 3D SGY cube. To introduce a cylinder, first of all load the SGY cube in the seismic frame File> Load Seismic file



The cube in 3D (optional view):



Then click <u>Run> Velocity Model Insert cylinder in Model Cube</u>

Specify the extension of the cylinder across $\underline{X}, \underline{Y}$ and \underline{Z} axes, as well as its <u>Radius</u> and © 2019-2021

Internal value. Insert cylinder upon completion.

Cylinder				x
Input Model File : C:\	Users\Stefan\Desk	top\3D mode	ling\DUPLEX_V	ELOCITY_MODI
Axis of symmetry :				
from X = 2000	Y =	50	Z =	2200
to X = 2000	Y =	4000	Z =	2200
Radius of Cy	linder R = 1000			
Internal value (ve	locity) V = 6000			
Output Model File : C:\	Users\Stefan\Desk	top\3D mode	ling\DUPLEX_V	ELOCITY_MODI
		Inser	t cylinder	Cancel



Please bear in mind that X scale \neq Z scale in the figure above.

To introduce a tetrahedron, likewise load the SGY cube in the seismic frame <u>File></u> Load Seismic file, then <u>Run></u> Insert Tetrahedron in Model Cube. Now you will specify the coordinates of the 4 vertices, as well as the <u>Internal value</u> of this tetrahedron.

Tetrahedron						×
Input Model File :	C: \Users\Ste	fan \Desktop \;	3D modeling	Job3D-01\DUP	LEX_VELOCITY_]
Vertices of tetra	hedron					
Vertex 1: X =	2000	Y =	2000	Z =	100	
Vertex 2: X =	2000	Y =	3900	Z =	2400	
Vertex 3: X =	400	Y =	100	Z =	2400	
Vertex 4: X =	3600	Y =	100	Z =	2400	
Internal value (v	velocity) V =	6000				
Output Model File :	C:\Users\Ste	fan \Desktop \;	3D modeling\	Job3D-01\DUP		
			Inser	rt tetrahedron	Cancel	



3.1.14 3D model building from well data

For instructions on how to import your logs, as well as your inclinometry and stratigraphic data, please follow the instructions from Section Помилка! Джерело посилання не найдено.

In order to build a 3D model from interpolated mapping of well logs, the user first needs to select the desired oil field from the <u>Database</u> (in the left window of Tesseral Pro). This is done by right clicking the field name and selecting Select field for the project.



Afterwards, the user needs to create a map with all the wells by clicking $\underline{\text{Map}} >$ Create Map (New Frame)>Show database WELLS.



The resulting blank map will contain all wells from the chosen oil field.

Next, go <u>Map > Calculation of horizon from well Tops</u> and select the stratigraphic layers that need to mapped.

Layer name	Cre	Wells	Top/Bottom	Strata name	
C1(v1+t) : Bottom		5	Bottom	C1(v1+t)	
C1s1 : Bottom		6	Bottom	C1s1	=
C1s2 : Bottom		6	Bottom	C1s2	
C1v2 : Bottom		6	Bottom	C1v2	
C2b : Bottom		6	Bottom	C2b	
C2m : Bottom		6	Bottom	C2m	
D3 : Bottom		3	Bottom	D3	
D3fm : Bottom		4	Bottom	D3fm	
•					•

<u>Automatic select layers</u> provides various selection criteria for choosing these layers. For example: <u>Only by all wells</u> automatically selects only the layers that are common to all wells in the project.

Once the layers have been selected the user will have to specify the interpolation method to be used in the <u>Choose mapping method</u> window(see Section 14.2.4)

Choose map	oping method	×
Method	Spline-approximation	OK
Analog	(do not use)	Cancel

Beyond this point the generated stratigraphic surfaces can be examined in $\underline{Map} > \sqrt{p}$

Manage/Delete Maps.

From this point on, the user should follow the instructions from Section 3.1.10 (i.e. starting with drawing a cross section across the surfaces first <u>Map>Section Mode</u>.



Followed by assigning values to the void layers created by the stratigraphic surfaces in the Map > Manage/ Delete Maps > 3D-model Properties.

3D-Model Properti	es	X		
Filling cells UP	T1(dr) : Bottom	▼ bottom ▼		
VALUE	2000			
Get values from	n map - not used -	•		
Use well log values				
Filling Empty Ce	ls (as default) OK	Cancel		

3.1.15 Building a thin layered 3D model

In order to build a 3D thin layered model from well data, the user will first need to create surfaces from the stratigraphic data in the <u>Database</u> wells and this procedure was explained in Section 3.1.14

For instructions on how to import log data, as well as stratigraphic and inclinometry data, please follow the instructions from Section *17.5*



Once all surfaces have been generated, the user will have to choose the well log data used for thin-layering by accessing Map>Load Well Logs

Select Well Logs
Well (All Wells)
AK DSK GK GKp GZ NGK NGKp PS PZ
OK Cancel

If you have not drawn a profile over your map frame already, please do so by going Map>Section Mode and draw the profile using the left mouse button.

© 2019-2021 Tesseral Technologies -*User Documentation*- Once the log data has been selected, the user will have to select the wells, which are to be used for 3D thin layered model building. In order to select a well, right click on it in the map frame and select <u>Add well to profile</u>. Repeat this for all desired wells.



Now, all your logs should appear in the cross section of the map frame:

The thin layering for the surfaces covered by the log data is assigned, as previously, in the Map > Manage/Delete Maps > 3D-model Properties tab by checking Use well log Values.

3D-Model Properties			•	x
Filling cells UP	C1s1:Bottom		▼ bottom	J
VALUE	0]		
Get values from r	nap - no	t used -		•
☑ Use well log v	alues			
Filling Empty Sells	(as default)	ОК	Ca	ncel
ld liles to fill in th	a all the grants	and from la	- data alead	lane out M

If you would like to fill in the all the surfaces from log data checkmark <u>Map ></u> <u>Manage/ Delete Maps > 3D-model Properties> Filling Empty</u> Cells (as default)>Use well log values (for all horizons).

3D-Model Propertie	25				
Filling cells UP	C1s1:Bottom	▼ bottom ▼			
VALUE	0				
Get values from	map - not used -				
🔽 Use well log	values				
Filling Empty Sells (as default) Filling of empty sells from the upper cells Base value 0 Use base seismogram - not used - V Use well log values (for all horizons)					
	ОК	Cancel			

Once all surfaces have been filled select <u>Run > Map Frame > Create 3D SEG-Y</u>

Create 3D Seg-Y Mo	odel						×
Output seg-y file C:\Users\Stefan\Desktop\Tesserral Pro testing new version\3D Model					sion\3D Model	.	
Grid parameters						51	
		Min	Μ	ax	Step	Size	
	x	5600	228	50	25	691	
	Y	7825	213	75	25	543	
	z	0	170	50	25	683	
	Set "Min" and "Max" from Map Frame						
						-	
	Filling Empty Sells (as default)						n I
Filling of empty sells from the upper cells Base value 2000							
	Use base seismogram - not used -						
•							
	Value range						
	Min	100		Max	10000		
					ОК	Cancel	
[

Specify the X, Y, Z dimensions you want for your 3D model, the grid sampling, as well as the <u>Filling cells</u> value with which you want to fill the remaining blank layer(s).

If you want to fill the remaining blank layer(s) from a base seismogram (i.e. from 3D SGY cube), then load it in the <u>Use base seismogram</u>.

Here, you can also introduce limitations to the min. and max. values for the thin layering in the $\underline{Value Range}$.

Finally, after clicking OK a thin layered cube from log data will be generated.





3.1.16 Building 3D model with complex faults using 3D View frame

To create from scratch or edit a 3D model use 3D View > 3D Model Edit Mode. If the model is created from scratch, the dialog Create 3D Model is appeared. Specify there coordinates of the model cube boundaries and the background compressional velocity. The program proposes immediately to create a Model frame directly related to the 3D model and shows the dialog Model Properties. (The Model frame is used to edit the model vertical sections.) In most cases it is enough to press OK. The default model consists of just four vertical sections corresponded to the cube boundaries of min and max X, min and max Y. To select one of the sections for editing in the Model frame drag the dashed section boundary along Y by mouse in the 3D View frame. The section nearest to the boundary at left mouse button release is selected. An alternative is to use the keyboard key combinations CTRL+↑ or CTRL+↓ within either the 3D View or the Model frame.



An active (selected) slice of the model cube which is shown in the Model frame can be edited similarly to 2D models. The main difference is requirement for any created polygon to be of type "top". (Other types are disabled.). The program keeps equal number of polyline vertices in each the polygon top boundary. It is supported by automatic inserting of insufficient vertices. Similarly any polygon created in the active section will be similarly created in other sections with interpolation between the nearest upper and down polygons. Similarly deletion of either

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single vertex or a whole polygon is repeated in all other vertical sections of the model. But drugging a polygon vertex does not affect vertices of other correspondent polygons in other sections. This is the method of drawing complex enough 3D structures.

4 U U -200 300 400 500 Model Horizons 0ء φ00 700 dome ✓ ● bottom XZ Section · 🗸 🔹 0: 0 • 1:300 · • 2:400 The vertex (800, 400, -200) 3: 600 4:700 5: 1000 VZ Section • 0:0 · 🗸 🔹 1: 100 2:200 Ζ • 3:800 4: 900 - 🗸 🔹 5: 1000 5000 2000 X 0 The intersection line len 0 of the current XZ and YZ slices

Consider editing a 3D model using the next example of a trapezoidal prism.

Moving a vertex in one of the <u>Model</u> frames causes it to move in the associated Model frame if the vertex belongs to the intersection line of the current sections XZ and YZ. The vertex © 2019-2021 Tesseral Technologies -*User Documentation*- also moves in the <u>3D View</u> frame. The vertex can also be moved using the <u>Edit node</u> command of the vertex context menu in the <u>Model</u> frame. It allows entering the exact value at the point. Moving the vertex in the XZ section does not affect the Y-coordinate, just as moving in the YZ section does not change the X-coordinate of the vertex. You can also move the entire section along one of the coordinate axes OX or OY. To do this, drag-n-drop the dashed selection box while holding CTRL. Dragging the first and the last sections leads to a change in the boundaries of the model! (In the example the boundaries are sections of numbers 0 and 5.) The section can also be moved by the <u>Move</u> command of the selected frame context menu, which is accessible by clicking the right mouse button.



For a better understanding of the model grid geometry, hatching is used. Besides, you can hide/show mesh cells (using the checkbox <u>Show Mesh</u>). These options can be configured using the <u>3D View> 3D Model Properties</u> menu command or the <u>Properties</u> command of the <u>Object Tree</u> context menu:



There are visual options for better understanding the model grid geometry: grid lines and hatching, transparency. They are selected in <u>Model > Wells & Polygons > Polygon Fill Options</u>:

Well-log based polygon fill setting				
✓ Palette ✓ Hatching	OK			
☐ Top and bottom point connection	Cancel			

Uncheck "Palette" here for transparency of the polygons.

A model layer is compound by plain bounded octagonal grid cells created by the corresponded polygons of different sections. The correspondence is expressed via the same polygon ID. The 3D model layer properties are specified in the related Model frame as the correspondent polygon properties.

To enter a new layer in 3D model insert its top horizon by inserting a new polygon in the related Model frame as usually. To delete a layer select the polygon correspondent to its top horizon in the related Model frame and delete. Both menu and toolbar controls of the Model frame are used similarly as for 2D models.




To insert new vertical section in the model use the dashed section boundary context menu called by right mouse button click. Select the context menu command <u>Insert 3D Model Section</u>. New section is inserted just in the section boundary position along Y: no "regularization" of the section set is done. So be careful. To delete a vertical section, select it either by mouse or by the keyboard key combinations $CTRL+\uparrow$ or $CTRL+\downarrow$ in the 3D View frame. Select the context menu command <u>Delete 3D Model Section</u>. To shift the selected vertical section along either X or Y axis press CTRL and drag the dashed section boundary.

In order to see the model horizons in the <u>3D View</u> frame, disable the *editing mode* (the menu command <u>3D View > 3D Model Edit Mode</u>) and thus, activate the *view mode*. In the *editing mode*, only active (editable) sections are displayed, while in the *view mode*, all the vertical sections and horizons marked with checkmarks in the Object Tree are displayed. The checkboxes at the vertices of the <u>Horizons</u>, XZ Section and <u>YZ Section</u> Object Tree allow you to hide / show all the horizons, XZ sections or YZ sections, respectively, in both modes. Using the checkmark at the Model node, you can also hide / show the entire model.



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3D Model can be also initiated from the horizon maps stored in Map frame of the project. To do it call the menu command <u>3D View > Create 3D Model from Maps</u> and specify parameters in the appeared dialog. The list of horizon maps is editable: the maps deleted from the list by the below button are excluded from the 3D model but left untouched in the Map frame. Min and Max parameters of the dialog specify the model boundaries. There is a button to automatically fit the values by the list of horizon maps. Additional parameters Step and Size specify the model grid sampling.



Ready model is stored as a regular grid in SEG-Y cube format by the menu command <u>3D</u> <u>View > Export 3D Model to SEG-Y</u>. The resulting seismic cube can then be used to build a new 3D model. Such way, objects of complex shape can be inserted into a horizontally layered model. For example, so an additional horizon can be inserted above the trapezoidal prism in the considered model. Then one can specify its velocities, density and other properties using the previously exported SEG-Y cube as the background. This is done as usually in the polygon (horizon) properties dialog (see chapter <u>3.2.5</u>).



Another command <u>3D View > Export 3D Model to Text Files</u> exports separate model horizons in a text grid format.

3.2 Polygon creation and editing

After an empty model (Model Frame) is created, it has to be filled with geological objects of various rock physical properties. In the Tesseral Pro, polygons are used to represent geological objects. In model building, a polygon is characterized by a set of parameters, such as compressional- and shear-wave velocity, density, anisotropic parameters and fracturing. In such manner, any area of the model can be filled with polygons with determined properties.

During the setup of the modeling job (synthetic gathers calculation), a grid with the given step along the section direction and depth direction is created from the polygonal model. The parameters for each node of this grid are obtained from the polygon in which the node is located. If the location of a node is overlapped by several polygons, then its parameters are obtained from the upper-most polygon.

3.2.1 Create a polygon manually

Please select the menu $\underline{\texttt{Model}}$ using the mouse, and then select the command $\underline{\texttt{New}}$ $\underline{\texttt{Polygon}}.$



In the dialogue box <u>New Polygon</u>, please select or specify the polygon name (<u>Polygon Name</u>), and select the type of polygon to be created (<u>Polygon Type</u>). The following polygon types are supported:



• <u>Polygon Type</u>: <u>top&bottom</u> – the user needs to draw the top and bottom of the polygon. The right and left sides will match to the corresponding boundaries of background model (base polygon).

• <u>Polygon Type: top</u> – the user needs to draw only the top of the polygon. And then the other 3 boundaries will match the corresponding boundaries of background model (base polygon) automatically.



• <u>Polygon Type</u>: <u>bottom</u> – the user needs to draw only the bottom of the polygon. And then the other 3 boundaries will match the corresponding boundaries of background model (base polygon) automatically. Please note, if the top of the background model is located above the zero depth, the top of polygon will be set to the level of zero-depth.



• <u>Polygon Type: closed loop (object)</u> - a closed boundary need to be drawn.



• <u>Polygon Type: line (deep break)</u> - only a line is drawn, its thickness can be specified by the parameter width of line (m or ft) in the dialogue box New

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Polygon when this type of polygon is selected.



Once the polygon has been created please right-click the mouse or double click the left mouse button (must be done within the <u>Model Frame</u>). Then, a new extended dialogue box will appear for users to edit the polygon's properties. After exiting from the dialogue box <u>Polygon Properties</u>, users can add more nodes to the boundaries of the created polygon by clicking the mouse on its boundary.

3.2.2 Change polygon's shape

Users can select a polygon either using the mouse or from the list of all polygons in the toolbar. The boundaries of the selected polygon are shown in green color. If you want to add a node to a polygon boundary, press the left mouse button on the boundary of the polygon. If you want to remove an existing node, click it with the right mouse button. If you want to move a node, press-drag-release it with the left mouse button.

3.2.3 Move/copy a polygon

Select a polygon using the mouse by left-clicking on it or from the list in the toolbar, and then choose $\underline{Model} > \underline{Drag polygon}$ menu to move the selected polygon or $\underline{Model} > \underline{Copy Polygon}$ to copy it. After that, click the left mouse button inside the Model Frame to finish moving or copying.

3.2.4 Delete a polygon

Please use the menu command $\underline{\texttt{Model}}$ > $\underline{\texttt{Delete polygon}}$ to delete the selected polygon.

NOTE: To undo the previous action, please use the <u>Undo</u> command.

3.2.5 Edit polygon's properties

Please select a polygon with the mouse or from the list of polygons in the toolbar. The boundary of the selected polygon will be highlighted with a bold green line. Then, use the menu command Model > Edit polygon to edit the polygon's properties.

Polygon Type	·]			Border Smo	othing border	
Component	Units	Manually	-Value	-From Seismogram	From Log	
Compression Velocity	m/s	$\overline{\mathbf{v}}$	2200			
Density	kg/m^3		2086			
Shear Velocity	m/s		1270			
Anisotropy & Other Properties			By default	Property seismogram	Stratification Select Well-logs	•

<u>Polygon Name</u> is the actual name of the polygon. If a polygon reflects a layer in the well, it is recommended give it the name of that layer. In the <u>Polygon Name</u> drop-down list, the complete list of layers' names from the database is shown.

The group <u>Component</u> is for editing the velocity, density and other parameters for the polygon. If the <u>Manually</u> checkbox is not checked, the corresponding values will be calculated automatically from the other parameters using empirical formulae.

<u>From Log</u> – if checked, the polygon's properties will be obtained by interpolating the logging data. The <u>Select Well-logs</u> button is for selecting the curves in the <u>Model</u> <u>Frame</u> and specifying their type (velocity or density) and measurement units.

<u>From Seismogram</u> – if checked, the polygon's properties will be obtained from the data of the underlying seismic file. The <u>Property seismogram</u> button is for selecting the underlying seismic file in the <u>Model Frame</u> and specifying their type (velocity or density) and measurement units.

The \underline{By} default button is for saving the user-specified values as the default values for future use when a new polygon with the same name is created.

The <u>Smoothing border</u> checkbox is for smoothing the polygon's boundaries automatically. In case when the <u>Polygon Type</u> is <u>top&bottom</u>, the top and the bottom boundaries will be smoothed independently.



The <u>Drawing Properties</u> button is for setting the color filling of the polygon and the attributes of its boundaries. It is only for the visualization, not affecting the calculation of synthetic gathers.

3.2.6 Anisotropic/fracture/absorption parameters

To specify the anisotropy and/or fracturing parameters, press the <u>Anisotropy &</u> <u>Other Properties</u> button. Then, in the dialogue box <u>Anisotropy & Other</u> <u>Properties</u>, specify the value for each parameter shown in the pop-up dialogue box (shown below).

nisotropy & Other Prope	isotropy & Other Properties								
Thompsen's Parame	eters (Anisotropy)	——г	From Seismogr	am					
Epsilon 0	Delta 0	Relati	ve azimuth 0	deg					
Gamma 0	Phi 0	deg	Alpha 0	deg					
- Fracture	Dn	Dt	Alpha deg	Azimuth deg					
First Fracture	0	0	0	0					
🔲 Second Fracture	0	0	0	0					
Third Fracture	0	0	0	0					
Compressional O]	Г	3D extention					
– Sources type: Reflector – Muted		[<u> </u>	Cancel					

By default, each polygon is isotropic.

<u>Thompsen's Parameters</u>: ε (Epsilon), δ (Delta), γ (Gamma) and the inclination angle φ (Phi) of the symmetry axis of the transversal-isotropic (TI) background medium can be specified. The coefficients ε and δ determine the relative difference of the qP and qSV wave velocity in different propagation directions with respect to velocity along the symmetry axis of the background medium, and they are used only in the Elastic Anisotropy mode. The parameter γ determines the velocity variation of the qSH waves along different propagation direction, and it does not affect wavefield of a 2D modeling (it is added to make the description more complete and for future upgrade).

<u>Fracture</u> describes intensity of fracturing in the background medium, and is characterized by parameters δ_n (<u>Dn</u>), δ_t (<u>Dt</u>) and the fracturing inclination angle α (<u>Alpha</u>) with respect to the vertical direction. Each layer may have 0-3 different fracturing systems. The parameters δ_n (Dn), δ_t (Dt) should be within the limit of [0,...,1]. The inclination angle α (Alpha) is within the limit of [-90°,...,90°]. The parameters δ_n (Dn), δ_t (Dt) depend on the density of fractures, Poisson coefficient of the background medium and the type of materials filling in the fractures. These parameters affect both propagation velocities of all types of waves along different directions, as well as their dynamic properties (amplitude).

<u>Q-factor</u> is for specifying the parameters about the seismic energy absorption in viscoelastic medium. This parameter measures the attenuation of the wave amplitude for a wavelength. The Quality of <u>Compressional</u> and <u>Shear</u> waves can be specified separately.

Sources type: Reflector, the option Muted is for suppressing the wavefront generated by

the boundaries of all polygons when the source type is <u>Reflector</u>. Selection of the source type is described in the Section 5.1.

3.2.7 Order of polygon overlapping

All the polygons in the model are displayed in the same order as they appear in the polygon's list (the list in the main editing toolbar). Please use the menu command $\underline{Model} > \underline{Bring Polygon Forward}$ to move a polygon upward, and use the menu command $\underline{Model} > \underline{Bring Polygon Backward}$ to move a polygon downward. These commands move the polygon up/down one level, i.e. exchange the chosen polygon and the previous or next one. To set the correct order of overlapping polygons, users may need to repeat this command several times.

3.2.8 Base points

The base points are used to specify the components with linear gradient within the polygon. Firstly, select the polygon where you would like to add some base points. To add a base point to an active (selected) polygon, please choose the command <u>Add Base Point</u> in the context menu by clicking the right mouse button, or select the command in the menu <u>Model ></u> Base Points > Add Base Point.

Base Point			×
Component	- Units	- Manually	-Value
Compressional velocity	m/s		2200
Density	kg/m^3		2086
Shear velocity	m/s		1270
Coordinate Distance (X) 500 Depth (Z) 500	m		Cancel
			Cancel

Please specify the coordinates of the base points and the values of each component in the dialogue box <u>Base Point</u>. The gradient will be calculated automatically for any 2 adjacent base points:



To edit the parameters at a base point, please use the Edit Base Point command in

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context menu by right-clicking the base point or use the menu command <u>Model > Base</u> <u>Points > Edit Base Point</u> for the active base point marked by square with red edge. The base points may be relocated by the mouse (press-drag-release) or deleted by using the command <u>Delete Base Point</u> in the context menu or <u>Model > Base Points ></u> Delete Base Point in the to-level menu.

Also, it is possible to interpolate between base points while following the geometry of the polygon (i.e. like in well logs). To do that right click on the polygon and select <u>Polygon</u> Properties > Interpolate like well-logs.

olygon Type				Border		Base Points
top⊥	•			Smoo	othing border	Interpolate like well-logs (account the layer top and bottom horizon geometry)
Component	Units	Manually	Value	From Seismogram	From Log	
Compression Velocity	m/s	V	3000			
Density	kg/m^3		2200			
Shear Velocity	m/s		1730			
Anisotropy & Other Pro Porous Drawing Properties	operties	Com	By default	Property seismogram	Stratification Select Well-	logs OK Cancel
Anisotropy & Other Pro Porous Drawing Properties	Properties	Com 2600 277 2600 277 2600 600 777	By default ponents: value rar 00 2800 2900 00 700 800 900	Property seismogram	Stratification Select Well-	OK Cancel
Anisotropy & Other Pro Porous	>perties 2400 2500 2400 2500 1 1 1 460 460 1 460 460 1000	Com 2600 27 2600 27 200 27 200 27 200 27 200 77	By default ponents: value rar	Property seismogram	Stratification Select Well- 0 2300 2400 1 1 1 200 300 400	OK Cancel
Anisotropy & Other Pro Porous		Com 12 R 0.7 June 2600 27 2 2 2 2 2 2 2 2 2 2 2 2 2	By default	Property seismogram	Stratification Select Well- 0 2300 2400 1 1 1 200 300 400	OK Cancel

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The upper base point assigns the velocity at the very top of the polygon, while the lower base point - at the very bottom of the polygon and the generated gradient is uniform with respect to the geometry of the polygon (as shown above). The right panel is the *Model* Frame with a coarser illustration of the gradient (generated by the two base points-displayed as white squares), while the left panel is the corresponding SGY file with a finer illustration of the gradient.

3.2.9 Build polygons from well's intersection data

This feature is supported only for models built using wells with layers. Please see Section 3.1.4 for details about building models using well data.

Select the <u>Model</u> Frame and then select the command <u>Create polygon</u>. In the dialogue box <u>New Polygon</u>, specify the <u>Polygon Name</u> from the list of layer's codes in the database. These polygons need to have been created in advance using Top and Bottom Markers and be saved in the Database.

New Polygon		
Polygon Name Polygon Type top⊥	I BP6-3-1 Gankinskaya Kuznetsovskaya Lulinvorskaya NizhneBerezovskaya PK1 PK10 PK11 PK12 PK13 PK14 PK15	Border Smoothing border
	PK17	

If the name of a polygon matches at least one of layer names for the wells loaded into the model, you will be asked to build the polygon automatically from the layer intersection data.

TesseralPro	X
Do you wish to create polyg	on from wells layer automatically?
	<u>Y</u> es <u>N</u> o

Please see the results:



The automatic creation of a polygon group from several selected layers is supported, for which the menu command <u>Model > Wells & Polygons > Create Polygons</u> from Well Strata Marks is used.

Laver name	Cre	Wells	Top/Bottom	Strata name	
BP6-3-1 : Bottom		1	Bottom	BP6-3-1	_
BP6-3-1 : Top		1	Тор	BP6-3-1	
Gankinskaya : Bottom		4	Bottom	Gankinskaya	
Gankinskaya : Top		4	Тор	Gankinskaya	
✓ Kuznetsovskaya : Bottom		4	Bottom	Kuznetsovskaya	
Kuznetsovskaya : Top		4	Тор	Kuznetsovskaya	
🗹 Lulinvorskaya : Bottom		3	Bottom	Lulinvorskaya	
🗹 Lulinvorskaya : Top		3	Тор	Lulinvorskaya	
I al sector providence - protection		A	D-14	KE-LDl	

From the list of layers, select the ones you would like to see enclosed with polygons. The result will be a depth model created automatically.

1 🚽	nte	rsectio	onData_2.	tpa - Tesse	ralPro												X E
<u>F</u> ile		<u>D</u> ataba	ase <u>E</u> dit	t <u>V</u> iew	<u>M</u> odel M	<u>ap S</u> eis	mic 3D Vie	w <u>R</u> un	<u>H</u> elp								
	•	D	i 🖌 🛎	2 🖂	±₩	20	F 🔡	₽= 12	11. IX I	<u>🛛</u> 🔍 🔍	$(\mathbf{Q}, \mathbf{\Phi})$	100%	•	草 🖥			
		R 10	Sankinskay	/a			- 4	. 🔊 🕂		5 55	1	E 🕹	M				
í	Г	• 1 ²							1 1 1	A	120						
	1	*****	*******	********	******	*******	********	******	******	eeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeeee	*******	********	*******	**********	********	*******	******
	2	000		2200	24	00	2600		2800	3000		3200	3	400	3600		3800
														1			
	2	len (0	4000	8000	12000	16000	20000	24000	28000	32000	36000	40000	44000	48000	52000	
				12 DT		11 DT					13 DT				14		
	-	_		12901		12862					18300		_				
	-	۲ -															
		1			Atlimska	va					_						1
					Tavdinska	iya				Tavdins	skaya						
	H	+00			Lulinvorsk	aya				Lulinvor	rskaya			Lulinvors	kaya		400
-		+			Taliska												- 1
						a				lalisk	caya			Taliska	ya		
		500 -	Gankin	skaya -	Gankinsk	aya				Gankin	skaya			Gankinsl	aya		800
	-	-	Berezov	skava	Berezovsk	aya				Berezov	/skaya			Berezovs	kaya		
	1	200 Z	zhneBere	zovstava	zhneBerezo	vskaya				NizhneBere Kuznetso	ezovskava ovskava			VizhneBerez Kuznetsov	dvskaya skaya		1200
		7	Kuznetsc	yska 🗲		i i i ju				PK	1			<u></u>	-		[]
	-	-		1						PK	4						1
	1	600		1							5			<u>PK6</u>			1600
				1							8						
	-	-		£		1940				PK	10			DK 7 4	8		{
	k,									Ré							······
Synt	the	ic seisn	nograms cr	eating:	STEP 1: Cre	eate Veloci	ty Model >	STEP 2:	Acquisition Ge	eometry >	STEP 3: R	un modeling >	>	Hide			
poin	it: 1	78 x 5	mm,		1 frames s	elected			[

3.2.10 Build polygons from well logs (thin layering)

Tesseral Pro has the capability of building a thin-layered velocity model from well log data (particularly using acoustic log).

NOTE: To build a thin-layered model from well log data, it is recommended to start the process using the Wizard for model creation <u>From database WELLS</u>. Please see details in the Section 3.1.4.

STEP 1. Select the acoustic logs. Please select the acoustic logs (DT or AK) in the dialogue box <u>Model Properties</u> for the Model created by well data. To do this, check the checkbox near the <u>Log</u> button on the right hand side of the <u>Well data</u> group to the left or right of the well. Then click the <u>Log</u> button, and in the pop-up dialogue box <u>Log</u>, select the needed acoustic logs from the list of all well logs loaded into this model. To specify the polygon parameters from well log data correctly, please select <u>Compressional Velocity or dT</u> in the <u>Specification</u> parameter list, and <u>usec/m</u> as <u>Measurement unit</u> parameter for the selected logs.



After that, the well logs will be shown near the wells in the model.

STEP 2. Build polygon. The common "thick" polygons are used for the thin-layered models. These polygons may be built either manually (see Section 3.2.1) or by any of the automatic methods (see the Section 3.2.9 and the Section 14.2.7).

STEP 3. Set polygon components from logs (From Log). Please select a polygon and then choose the menu command $\underline{Model} > \underline{Edit}$ Polygon. If the acoustic logs are selected correctly (see STEP 1), the From Log checkbox should be enabled for the Compressional velocity component. Check this checkbox (From Log).

					Select Curves on	Model			×
Nygon Properties			•	-	Add >	Well-log name DT		Well-log type Compression Velocity or dT	Measure uni usec/m
Polygon Type	Fi	lling ti	he compone	nt	Delete < Auto-select <>	4			Cancel
Component Compression Velocity	m/s		value 2200	From Seismogra	m - From Log				
Density	kg/m^3	Γ	2086						
Shear Velocity	m/s	Γ	1270	Π					
Anisotropy & Other Properties			By default	Property seismogram	Stratification Select Wel	logs	•		
Drawing Properties						OK	Cancel		

NOTE: If the selection <u>From Log</u> is not enabled (is grayed), click <u>Select Well-</u> <u>logs</u> to select the correct acoustic logs into the model.

NOTE: After checking the <u>From Log</u> checkbox and clicking <u>OK</u>, the interpolation calculation for the components won't start immediately. And the <u>From Log</u> component value will overwrite the default value when the calculation starts.

If the steps above are done correctly, you will see the result similar to the figures below. To get the second picture you need to delete the upper polygon using "Delete Polygon" button.





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Polygon specifics while using well logs

The parameters of polygons built from well logs are calculated by interpolating the well log data along the layer. There are 3 modes of interpolation:

Polygon Properties Polygon Name 1			•			
Polygon Type top⊥ Border Smoothing border						
Component	Units	Manually	-Value	-From Seism	nogram From Log	
Compression Velocity	m/s		2200		N	
Density	kg/m^3		2086		Modes of well log data interpolation in polygons	
Shear Velocity	m/s		1270			
Anisotropy & Other Properties			By default	Proper seismog	am Stratification Stratification Interpolation parallel to the Top (Down lap) Interpolation parallel to the Bottom (Top lap)	
Drawing Properties					0K Cancel	

Stratification: uniform compression. Stretching is proportional to the layer's thickness.





• <u>Interpolation parallel to the Bottom (Top lap)</u>: The data interpolation will be "parallel" to the "Bottom" boundary of polygon.



OK Cancel

3.3 Build model from 2D/3D gathers

Tesseral Pro allows building a model by importing velocity models having the following formats: SEG-Y, SDS-PC, and TGR. A seismic model can be used during building of polygons as underlay or as a filling source for the polygons created by velocities.

NOTE: To build a model by gathers, it is recommended first to prepare it by the Wizard for building a model From SEISMIC file. Please see details in the Section 3.1.2.

While building the polygons, please use the seismic underlying image as a background "picture"; it is also recommended to adjust the model transparency using the command $\underline{Edit} > Palette$.

ĺ	Palette	
	Magnitude within 1800 2800 🗖 Edit	Palette transparency
	Palette type Default Incremental	
$\left(\right)$	Glow (%)	Ď
	Edit palette Discretization 9 🛨	
	1800 2000 2200 2400 2600 2800	
	OK Cancel	

3.3.1 Specify the polygon's components by underlying gather

In the dialogue box with polygon parameters (the menu command $\underline{Model} > \underline{Edit}$ <u>Polygon</u>), please define the option <u>From</u> <u>Seismogram</u> for any component. The <u>From</u> <u>Seismogram</u> button will be disabled (gray) if an underlying gather is not defined or if a component is not selected for the gather (please see details in the Section 3.1.2).

F FromSeismogram.tpa - TesseralPro				
File Database Edit View Model M	1ap Seismic 3D View Run Hel	p		
▶ □ ≌ ■ ⊇ ≌ 控 😣	🛛 🗇 🛃 🏭 🛂 🕍 🖺	$\boxed{\mathbb{M}} \boxtimes \bigcirc \bigcirc$		
🗩 🔀 C1v2		🗙 🤜 🤜 🕵 🐄 💷	🗈 🔽 💥	
		A	<u> </u>	
8000 100	Polygon Droportion	Model		×
			The component value in the	gather
	Polygon Name C1v2	•	The component value in the	guiller
len 0 400 800	Polygon Type		Border	
1 11	top⊥ 💌		Smoothing border	
	Component Units	- Manually - Value - From Se	internet from Log	
Trun	Lompression Velocity 17/s		1	
4000	Density Ib/ft^3			
	Shear Velocity ft/s			
			Charlie and an	
	Anisotropy & Other Properties	By default seism	nogram Select Well-logs	
C2b				
8000 -C1s2				
	Drawing Properties	/	OK	Cancel
C1=1				
12000		×		
- <u>C1v2</u>				
Synthetic seismograms creating: STEP 1: Cr	eate Velocity Model > STEP 2: Acqu	isition Geometry > STEP 3: Run	modeling > Hide	
For Help, press F1				

3.3.2 Thomson- Tsvankin's Anisotropy Parameters

It also now possible to run 2.5D Elastic Modelling for mediums with orthorhombic anisotropy. An orthorhombic medium can be described by 7 dimensionless <u>Thomson-Tsvankin</u> parameters. They can be accessed in <u>Polygon Properties > Anisotropy & Other</u> <u>Properties >Thomson's Tsvankin parameters</u>

dvanced Polyg	on Anisotr	opy Parar	neters			X		
Warning. These settings will be used for 2D and 2.5D anisotropic simulation. For other modeling methods these settings will be ignored.								
Thomsen-Tsvankin's Anisotropy Parameters								
Epsilon1 Epsilon2 Delta1 Delta2 Delta3								
٥	0	0	()	0			
	Gamma	L G	amma2	Azimuth				
	0	0		0				
		Con	ivert↓					
 Stiffness Ten 	sor (2-index 2	: Voigt mat 3	rix notation) 4) 5	6			
0	0	0	0	0	0	1		
	0	0	0	0	0	2		
		0	0	0	0	3		
			0	0	0	4		
				0	0	5		
					0	6		

In the <u>Advanced Polygon Anisotropy Parameters</u> window the user can either specify the <u>Thomson-Tsvankin's Anisotropy Parameters</u> and calculate the Elastic Stiffness Coefficients or directly specify the <u>Stiffness Tensor</u> for the chosen polygon.

3.3.3 Porous Medium Parameters

The user can now specify the porous medium parameters for any polygon in the model. In order to access these parameters- right click on the polygon of interest and select \underline{Edit} Polygon > Porous

Polygon Type	•			Border	thing border
Component	Units	Manually	Value	From Seismogram	From Log
Compression Velocity	m/s	V	2500		
Density	kg/m^3		2200		
Shear Velocity	m/s		1450		
Anisotropy & Other Properties			Porous By derault	Property seismogram	Interpolation parallel to the Bottom (Top Iap) 💌

Once the <u>Porosity</u> is specified, along with the elastic wave velocities and density for the <u>Mineral</u>, <u>Dry Rock</u> and <u>Fluid</u>, the saturated rock velocities and bulk density in Polygon properties window will change accordingly(i.e. based on Gassman's equation).

Po	rous Medium Parameters	×
Γ	Mineral	
	Compressioanl Velocity : 6000	m/s
	Shear Velocity : 2900	m/s
	Density: 2750	kg/m^3
	Dry rock (Skeleton with Mineral)	
	Shear Velocity : 2673.7	m/s
	Compressional Velocity : 5316.3	m/s
	Fluid	
	Compressional Velocity : 1500	m/s
	Density: 1000	kg/m^3
	Porosity: 15	%
	OK	



4 Acquisition geometry for 2D

Sources are shown as triangles. To make a source active (selected) in the <u>Model</u> Frame, click it with the left mouse button. The active source will be filled in grey color. The receivers associated with the active source are shown as black squares. The other receivers are shown as grey squares. To move sources or receivers manually, use the mouse by pressing-dragging-releasing.

The spread of sources (shot points) and receivers (receiving points) are designed by choosing $\underline{Model} > \underline{Acquisition}$ Geometry menu command. In the dialogue box, the number of sources/receivers, their intervals and positions can be specified, and every source can be associated with a group of receivers. The users will be offered to arrange the sources/receivers geometry using a Wizard.



Since it is quite complicated to adjust the spread manually, it is recommended to use the Wizard.

NOTE: The dialogue box <u>Acquisition</u> Geometry Wizard is always launched at the very beginning of model creation.

In the Tesseral Pro, several acquisition design schemes can be implemented. Depending on the selected scheme, the Wizard may have 1~4 dialogue boxes.

4.1 Receivers move with source

The receivers are positioned in relation to one of the sources, and then they are repeated for other sources of the model.

STEP 1. Acquisition geometry

Observation scheme		×
Move receivers with source Zero-offset shooting Fixed reseiver position		Select acquisition geometry
C VSP(moving source)	C Dipole VSP	
C Load from file	C Load from SPS-file	
< <u>B</u> ack	Next > Cancel	Help

In the dialogue box <u>Observation scheme</u>, please select <u>Move receivers with</u> <u>source</u>. When this mode is chosen, you should first provide the source layout, followed by the layout of receives *relative to the same source*. As a result the receiver spread will have the same distribution for every single source.

STEP 2. **Sources** – In the dialogue box <u>Sources</u>, please select the set of parameters to be set from the list, and then enter the values for each empty parameter cell. The sources will be automatically placed uniformly along the acquisition surface (above the top edge of the model polygons).

C Number & step	Number of sources
Number Step From & step All parameters Select the para	Step 40 m From 100 m To 260 m rameters to set

<u>From</u> – is the starting position of the source line along the model section (profile) <u>To</u> – is the ending position of the source line along the model section (profile) <u>Step</u> – source interval **NOTE**: These parameters are related with each other by a simple relation: Number = To –From / Step + 1. Therefore, changing one of these parameters leads to recalculation of others.

STEP 3. Receivers	(for the acq	uisition geometr	ry "Move red	ceivers with	source")
--------------------------	--------------	------------------	--------------	--------------	----------

Receivers (geophones)	×
 Numbrer & step Step & from & to Number & step & from All parameters Number Step Specify 'From' and 'To' as shifts from current 	Number 40 Step 20 m From 140 m To 920 m
< <u>B</u> ack Finis	h Cancel Help

Specify the receiver distribution in the dialogue box <u>Receivers</u> (geophones). The parameters <u>From</u> and <u>To</u> do not represent the absolute distance relative to the profile origin, but the relative shift with respect to its corresponding source (negative value means placement to the left of its respective source).

4.2 Receivers at fixed position

The receivers and the sources are positioned independently. Thus, for each source, a group of receivers have to be selected.

STEP 1. Acquisition geometry

In the dialogue box Observation scheme, please select Fixed receiver position. In the following dialogue box, you should specify the source line independently, and then specify the group of receivers for each source.

STEP 2. Sources (for the acquisition geometry "Fixed receiver position") – The dialogue box <u>Sources</u> is the same for all types of acquisition geometries. More detailed information is given above.

STEP 3. Receivers (for the acquisition geometry "Fixed receiver position")

Receivers (geophones)			×
C Numbrer & step C Step & from & to	Number	51 🕂	
O Number & step & from	Step	20	m
O All parameters	From	0	m
O Number	То	1000	m
 Specify 'From' and 'To' as shifts along the p 	rofile line		
< <u>B</u> ack <u>N</u> ext	> 0	Cancel	Help

For the scheme "Fixed receiver position", the dialogue box <u>Receivers</u> (geophones) is similar to the dialogue box <u>Sources</u>. The parameters <u>From</u> and <u>To</u> specify distance along the profile line of the model. Please see the detailed description (for the dialogue box Sources) above.

Please specify the number of receivers (from the whole receiver line) used both to the left and to the right of the source.
Receivers (Geophones)
Receivers are at fixed position. Specify the receiver range associated with current shot.
Number of valid receivers at LEFT side of source
< <u>B</u> ack Finish Cancel Help

4.3 Zero offset

In this scheme, each source has only one receiver with the same coordinates. It is mainly used for ray tracing.

STEP 1. Acquisition geometry

In the dialogue box <u>Observation scheme</u>, please select the option <u>Zero-offset</u> <u>shooting</u>. In the next dialogue box, you should specify the source line. Receivers will be positioned automatically in a way that only one receiver is assigned to each source and the coordinates of each receiver will be identical to its corresponding source.

STEP 2. Sources (for the acquisition geometry "Zero-offset shooting") – The dialogue box <u>Sources</u> is the same for all the acquisition geometries. The more detailed description can be found in the Section 4.1.

4.4 VSP and VSP with ascending receivers

It is used for designing VSP acquisition geometry for the case when all sources are located on the surface. The receiver line can be fixed or ascending inside the well.



STEP 1. Acquisition scheme - In the dialogue box Observation scheme, select VSP(moving source).

Observation scheme	×
C Move receivers with source C Zero-offset shooting C Fixed reseiver position	
VSP (* VSP(moving source))	C Dipole VSP
C Load from file	C Load from SPS-file
< <u>B</u> ack	Next > Cancel Help

STEP 2. Sources – The dialogue box <u>Sources</u> is similar to other acquisition schemes.

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The detailed description is in the Section *4.1*. **STEP 3. Receivers**

Receivers (geophones)			×	
Numbrer & step Step & from & to Number & step & from All parameters	Number Step From	15 ÷	m	
C Number C Step	То	860	m	
Specify 'From' as model top and 'To' as moo	del bottom			
< <u>B</u> ack <u>N</u> ext	> (Cancel	Help	

In the dialogue box <u>Receivers</u> (geophones), the receivers spread is specified for the first source.

STEP 4.	Receivers	(Additional	parameters)
~		(p

Receivers (Geophones)	x
Receiver Layout	
Vertical line 300 m	
O Well	
Move receivers for every source by -80 m	
< <u>B</u> ack Finish Cancel Help	

Specify the way receivers should be positioned: along the vertical line or along the well. The well may be selected from the list of wells, which are used in the model (in the Section 12.1, it is described how to add a well into the model).

Below is an example of receiver spread along a well



4.5 VSP dipole

Both sources and receivers are located inside the well.



STEP 1. Acquisition scheme

In the dialogue box Observation scheme select Dipole VSP.

STEP 2. Sources – The dialogue box <u>Sources</u> is the same as other acquisition schemes. The only difference is that the sources are located along a vertical line or along the well.

STEP 3. Receivers – In the dialogue box <u>Receivers</u> (geophones), like in the acquisition scheme 4.1, the layout of receivers for the first source needs to be specified.

STEP 4. Receivers (Additional parameters)

Select one of the 2 options how the receivers are located: along a vertical line or along the well.

The parameter <u>Move receivers for every source by</u> is used for the acquisition scheme when the receivers are moving up along the well during the seismic observations.

4.6 Load acquisition geometry from gathers

If you have field gathers then the information on sources and receivers coordinates from the trace headers may be used to assign the acquisition scheme for a model.

STEP 1. Acquisition scheme

In the Observation scheme dialogue box, select Load from seismogram. In the next standard <u>File open</u> dialogue box, select the seismic file. All the sources and receivers will be loaded from the trace's header of the selected gather.

4.7 Load acquisition scheme from SPS files

STEP 1. Acquisition scheme

In the dialogue box <u>Observation scheme</u>, select <u>Load from SPS-file</u>. In the next dialogue box <u>SPS-files load</u>, select the SPS files. If you use the SPS file of a 3D spread, then in the group <u>Sources and receivers selection</u>, adjust the criteria for selecting sources and receivers to be loaded into the model and the binning size.

SPS-files load			×
Sources File	C:\Sheldon\TestingOfTesse	eralPro\Tesseral 3D Files\S	PS\Sw1.s01
Receivers File	C:\Sheldon\TestingOfTesse	eralPro\Tesseral 3D Files\S	PS\Sw1.r01
Shot-Receiver Relation File	C:\Sheldon\TestingOfTesse	eralPro\Tesseral 3D Files\S	PS\Sw1.x01
Sources and receivers selectio	n vay from the profile line	50 m	
Align the selected source/received	rs by bin	10 m	
		ОК	Cancel

In the next dialogue box Map, select the model section along the receiver line.



If the model length is smaller than the length of the selected profile in the Map dialogue,

you will be asked to correct (enlarge) the model. Tesseral Pro has the capability of creating a model using only SPS files (see Section 3.1.6 for more details).

4.8 Standard dialogue box for acquisition geometry

In addition to using Wizard for the sources and receivers layout, the integrated dialogue box can be used, which is activated by $\underline{Model} > \underline{Acquisition Geometry}$. Then select \underline{No} when asked to run Acquisition Geometry Wizard.

Acquisition Geometry	Launch t from the	the Wizard directly dialog	X
Sources shot points	Survey Geometry	Receivers (geopho	nes)
Number 5 🕂	>>>> Acquisition Geometry WIZARD >>>>	Number	15 🛨
Step 80 m	C All reseivers for every source	Step [40 m
From 200 m	Move receivers for every source by 80 m	From	100 m
To 520 m	C Move receivers with source	To [660 m
- Sources Allocation	Active source (use only in alignment "Move 0	- Receivers Allocatio	n
Cable interval	Distance from active source to left side model 200	Cable interval	
C Ground surface		C Ground surfac	e
O Polygon 0 (base) 💌	C Fixed receiver position	C Polygon 0 (ba	ase) 💌
C Well	Specify the receiver range associated with current shot	C Well	v
C Horizontal line 0 m	Number of valid receivers at LEFT side of RIGHT side of	C Horizontal line	0 m
Vertical line 500 m	source 15 2 21 Source	 Vertical line 	500 m
C Free	Specify the sources and	C Free	
	Load		
Model Length 1000 m	C Load from Gather Load		
Margin (use to modeling) 250	C Load from SPS-file Load	ОК	Cancel

The group <u>Sources</u> is for specifying the source layout, and the group <u>Receivers(geophones)</u> is to specify the receiver layout. The group of <u>Sources</u> <u>Allocation</u> or <u>Receivers Allocation</u> is to specify the line along which the sources or receivers will be positioned. If you select the option <u>Well</u> and a well from the list, then the sources (receivers) will be positioned along the selected well, as shown in the figure below.



If you select the option <u>Free</u> in the group <u>Sources</u> <u>Allocation</u> or <u>Receivers</u> <u>Allocation</u>, then each source (receiver) can be positioned in the model independently from each other. For the other options, all sources and receivers will be positioned as a group along a specific line.

5 Synthetic gather calculation

Before launching the job of computing synthetic gather, a velocity model (Section 3) and the corresponding acquisition geometry (Section 4) needs to be designed firstly and then the project has to be saved by using the command $\underline{File} > \underline{Save Project}$.

 $\frac{Please use the menu command <u>Run > Run 2D Modeling or <u>Run > Run 3D Modeling</u> to open the modeling parameter specification dialogue.$ </u>

5.1 Modeling methods

General			×
Modeling Procedure Acoustic Modeling			
Source shot points	From #: 1 To #: 5	All	Active
Shotgahter Record			
Step 2 ms			
Save results to C:\Sheldon\TestingOfT	esseralPro		Browse
< <u>B</u> ack	Next > Finish	Cancel	Help

The <u>Modeling</u> <u>Procedure</u> parameter is for selecting the method used for solving the wave equation. The available modeling methods include:

• <u>2D Vertical Incidence</u> is to simulate the vertical propagation of waves for horizontal boundaries. It allows quick evaluation of the arrival time and the amplitudes of the reflected waves in the time section under the condition of strict 1D propagation of seismic energy.

• <u>2D Scalar</u> is for the scalar model of the medium (i.e., liquid approximation without considering variation of density). It only takes into account the variation of compressional velocity and it is the quickest method for the modeling of 2D wave propagation.

• <u>2D Acoustic</u> is for the acoustic model of the medium, which takes into account the variation of compressional velocity and density.

• <u>Acoustic without multiples</u> is for quickly obtaining the time section of the acoustic model of the medium. As a whole, it corresponds to the exploding interface mode of other methods, but it does not take into account the multiples and the image contains fewer noises. It enables users to intuitively understand the influence of multiples on the gather and seismic image by comparing with standard acoustic method.

• <u>2D Elastic</u> is for an isotropic elastic model. This is the main modeling method, which can simulate the 2D propagation of seismic energy in solid media by taking into account the effects of wave-mode conversion and the shear waves, as well as the effect of quasi-anisotropy caused by a stack of inter-bedded thin layers.

• <u>2D Elastic Anisotropic</u> is for a 2D-anisotropic elastic model and takes into account the variation of physical properties in horizontal and vertical direction. The input model can have up to 3 systems of 2D-oriented fracturing. This modeling method can simulate the seismic energy propagation in anisotropic medium. The anisotropic parameters and/or fracturing parameters have to be specified by the user. If these parameters are not specified, the algorithm is equivalent to the isotropic elastic method.

• <u>2D Visco-Elastic</u> is for a visco-elastic model and can be used to evaluate the effects of seismic energy absorption. It also takes into account the velocity dispersion. The quality factor needs to be specified by the user. If this parameter is not specified, this algorithm is equivalent to Elastic Modeling. This modeling method allows users to examine the influence of fluid on wave propagation.

• <u>2D Eikonal Ray Tracing</u> is the ray-tracing method for isotropic and anisotropic

medium and is based on the high-frequency (optical) approximation of wave-equation modeling. It does not calculate the multiples but may take into account converted waves at the reflector. The method is not suitable for a thin-layered model. This method enables users to evaluate horizons' illumination taking into account reflection waves. (Other methods can only show incident wave energy instead of the illumination).

• <u>2.5D Elastic/Elastic Anisotropic + Visco-Elastic*</u> is for 3D isotropic or anisotropic elastic model with arbitrarily-oriented fracturing sets in 3D space. It is assumed that the variation of the rock properties goes along the model's profile, while the variation perpendicular to the model's plane (along the Y axis) is negligible. This method can generate not only 2D/3C gathers but also 3D/3C ones, and in case of a vector source even 3D/9C gathers can be generated. The parameters of anisotropy and fracturing have to be specified. The azimuth is relative to the profile line of the model. Additionally modeling of frequency dependent attenuation (Visco-Elastic) is also an option. 2D 3D

• <u>3D Vertical Incidence</u> is to simulate the vertical propagation of waves for horizontal boundaries. It allows quick evaluation of the arrival time and the amplitudes of the reflected waves in the time section under the condition of strict 1D propagation of seismic energy. To access this method please first create a 3D observation system (See 7) then <u>Run></u> <u>Run 3D modeling</u>

	Mo	deling Procedure:	3D Ver	rtical Incidence			•	
nput								
P-Veloci	ty Cube File	1\DUPLEX_VELC	CITY_M	ODEL_newsort_	revers.s	gy Bro	owse Re	equired
S-Velocity Cube File						Bro	owse No	ot Used
Density	Cube File					Bro	owse	Auto
Quality	Cube File					Bro	owse	isabled
Start	0	ms	Auto X min	35	m	X max	3955	m
Stop	4000	ms	Y min	35	m	Ymax	4515	m
Step	2	ms	Z min	0	m	Zmax	4070	m
	results to	C:\Users\Stef	an \ Deskt	op\Tesserral Pr	o testing	new versi	Brow	se
Save	Courte corri			b. launch using	existing	runtask.in	i	
Save i	t the task file	Do not crea	te new jo	in a series of the series of t	, crub di ig			

• <u>3D-3C Acoustic</u>, <u>Elastic</u>* allows approximating wave propagation in conditions of realistically heterogeneous (in all 3 directions X, Y and Z) medium. This modelling can be applied to the objects like reefs, salt domes, different kinds of collapse/breakthrough chimneys or steeply inclined faults etc. in the areas where an accurate 3D reservoir characterization is required.

Note*: 2.5-3D-3C Full-wave (finite-difference) modelling, due to its computational intensity, is based on *Parallel Options* including *multi-core, -node, -GPU* solutions allowing to run such simulations in a feasible turnaround time.

To access this method please first create a 3D observation system (See 7) then $\underline{\texttt{Run}}$ Run 3D modeling.

• <u>3D-3C</u> elastic TTI Anisotropic method. For this method the anisotropic parameters <u>Epsilon</u>, <u>Delta</u> and <u>Gamma</u> of the medium needs to be assigned. Either constant values or seismic cubes are assigned for Thomsen's parameters in the <u>3D</u> <u>Anisotropic Modeling</u> window. The angle <u>Phi</u> (i.e. the angle from the vertical), as well as the <u>Azimuth</u> of the TTI axis needs to be specified.

Anisotropic Model	eters n	
You can specify Thomsen param	either a constant value or a seismic cube for non-ze	ro
Epsilon	0.2	Browse
Delta	-0.1	Browse
Gamma	0.03	Browse
Phi Azimuth	30 45	Browse
	< <u>B</u> ack <u>N</u> ext > F	inish Cancel Help

For the Orthorhombic (VTI/HTI) as written, both Phi and Azimuth can be either 0 or 90 degrees.

	rameters
 Approxima 	ation
Orthor	rombic (VTI/HTI)
You can spec Thomsen par	cify either a constant value or a seismic cube for non-zero rameters
Epsilon	0.2 Browse
Delta	-0.1 Browse
Gamma	0.03 Browse
In orthoromb	oic (VTI/HTI) approximation both phi and azimuth can be either 0 or 90 degrees
In orthoromb Phi Azimuth	pic (VTI/HTI) approximation both phi and azimuth can be either 0 or 90 degrees 90 Browse 90 Browse
In orthoromb Phi Azimuth	bic (VTI/HTI) approximation both phi and azimuth can be either 0 or 90 degrees 90 Browse 90 Browse
In orthoromb Phi Azimuth	bic (VTI/HTI) approximation both phi and azimuth can be either 0 or 90 degrees 90 90 Browse 90 Browse
In orthoromb Phi Azimuth	bic (VTI/HTI) approximation both phi and azimuth can be either 0 or 90 degrees 90 Browse 90 Browse 90 Browse
In orthoromb Phi Azimuth	bic (VTI/HTI) approximation both phi and azimuth can be either 0 or 90 degrees 90 90 Browse 90 Browse
In orthoromb Phi Azimuth	bic (VTI/HTI) approximation both phi and azimuth can be either 0 or 90 degrees 90 90 Browse 90 Browse

To access this method please, create a 3D observation system first (see 7), then $\underline{Run} > Run 3D$ modeling.

• <u>Haskell-Thomson</u> is a 2D/3D modelling method that is strictly designed for VTI mediums. This method, in fact, is the 3D-method for a horizontally layered medium, but it is using for 2D-models also. If this method is applied to the medium with the curved boundaries, it implicitly builds a horizontally layered medium, based on the velocities just below the source. The main advantage of this method is the possibility to calculate various types of wave fields (P, SV, SH) separately. This method is not very appropriate to the thin-layered modelx, because the calculation time is in proportion to the number of boundaries. With this method it is possible to simulate point sources only, and the sources and receivers are assumed to be located on a common horizontal surface.

This method implements spectral decomposition along X, Y and also time and as a result the wave field propagates in 1D along the Z axis. The method essentially allows the user to generate partial wave fields by allowing the user to choose the type of propagating (i.e. \underline{Down} <u>Wave</u>) and receiving (i.e. <u>Generate wave type</u>) waves, while allowing full wave mode conversion in inter-bedded layers.

Addition	
	Threads per process Max -
	Produce time field None -
	GPU Enable GPU OpenCL (if available)
	Haskell-Thomson Additional Options
	Down wave P 🔹
	Number Slowness coefficient by x 1200 601 -
	Slowness coefficient by y 1200 601
	☑ Auto calc. number of slowness
	Generate waves type P&S
	Components: value range
< <u>B</u> ack	Next > Finish Cancel Help

The <u>Slowness Coefficient by x</u> and <u>Slowness Coefficient by y</u> (1200 in this case), implies that the range of slowness is limited by 1200/Vs where Vs is the minimum shear wave velocity in the model. The <u>Number</u> parameter determines the number of used harmonics, (i.e. slowness). With these two variables all possible reflected and surface waves can be modeled, provided that a large <u>Number</u> of slowness is used (i.e. 601). A smaller number of slowness would result in modeling of reflected waves only, while supressing the surface ones (e.g. Rayleigh Waves).

• <u>3D-3C visco elastic method</u> is used to evaluate the effects of seismic energy absorption in a 3D medium with or without any VTI/HTI anisotropy. For this method the <u>Quality Cube file</u> (i.e. Q factor cube) needs to be loaded in the <u>3D Modeling</u> <u>General Properties</u> tab for the <u>3D Elastic</u> or <u>3D Elastic Anisotropic</u> modelling procedure.

	Mad	loling Drocodurou		atic Anicotroni				
	MOC	leling Procedure:	JU Elas	suc Anisotropi	IC		•	
Input								
P-Veloc	ity Cube File	1/DUPLEX_VELC	CITY_MC	DEL_newsort	t_revers.s	gy Bro	owse Re	equired
S-Veloc	ity Cube File					Bro	owse	Auto
Density	Cube File					Bro	owse	Auto
Quality	Cube File	1				Bro	owse	nabled
Shotgahte	er Record		Model Bou	Indaries				
Start	0	ms	X min	35	m	X max	3955	m
	4000	ms	Y min	35	m	Ymax	4515	m
Stop		_				7 may	4070	m
Stop Step	2	ms	Z min	0	m	2 1107	1070	
Stop Step Save	2 results to	ms C:\Users\Stef	Z min an \Deskto	0 p\Tesserral F	Pro testing	new versi	Brow	se

To access this method this method please first create a 3D observation system (See θ) then access <u>Run> Run 3D modeling</u>.

Also, in order for velocity dispersion (i.e. frequency dependency) to be taken into account, the <u>Number of relaxation mechanisms</u> must be specified in the <u>3D</u> <u>Modeling Calculation Properties</u>. <u>Use Apparent Velocities</u> ties the assigned velocity of the medium to the assigned frequency. Consequently, as the bandwidth of the signal is reduced (due to <u>Qs</u> and <u>Qp</u>), so is the velocity. This is absolutely consistent with applied geophysics. Whereas <u>Use Intrinsic Velocities</u> ties the assigned velocity to zero frequency and as a result the velocity of the propagating waves is greater than the assigned velocity in the model. The 3D viscoelastic method is most generally used to examine the effect of fluid on full 3D wave propagation. For more details see: <u>http://petrowiki.org/Acoustic velocity dispersion and attervation</u>

http://petrowiki.org/Acoustic_velocity_dispersion_and_attenuation

Addition	×
Addition Computation Grid Properties Cell (dx, dz) 1 m auto Tact (dt) 0.05 ms auto Generate snapshots Start 0 ms Step 200 ms Generate by every 1 source Anisotropy/Fracturing Attenuation (Quality)	Threads per process Max Produce time field None GPU Enable GPU OpenCL (if available)
Number of relaxation mechanism Use apparent velocities Use intrinistic velocities Margin 6000 auto	 ✓ Higher Order Approximation (better quality) PML for invisible boundaries (better suppresses reflections in most cases) Components: value range Next > Finish Cancel Help

The following applies to 2D modeling only.

If the <u>Source</u> is specified as <u>shot</u> <u>points</u>, the synthetic gathers are generated successively from each source for the group of receivers associated with this source. Once the modeling job for all sources is completed, a single merged shot gather is obtained. It has the flexibility of generating the synthetic gathers for only a part of the sources by using the parameters From # and To #.

If the <u>Source</u> is specified as <u>reflector</u> (exploding reflector), it is assumed that the visible part of the boundary of each of polygons may represent a line source oriented upwards to the surface of the model. Users can specify the parameter <u>Max angle (deg)</u> to limit the maximum angle of the boundary to be used as exploding reflector (by default it is limited by a 30 degree angle).



And the method of the acquisition system in the Frame Model is changed: the sources are not shown and the parts of the boundaries emitting the wave are shown as bold dotted lines.

NOTE: It is possible to switch off the wave generation from all the boundaries of any polygon. To do it, select the polygon, call dialog box <u>Polygon Properties</u> by menu command <u>Model > Edit Polygon</u>, click the button <u>Anisotropy & Other</u> <u>Properties</u> in the dialogue box, and select <u>Muted</u> in <u>Sources type: Reflector</u> group.

If the <u>Source</u> is specified as <u>surface</u> (exploding surface), the whole ground surface is excited at the same time. It can enable the modeling of plane-wave propagation.



NOTE: After the gather is calculated using the method of exploding surface or exploding reflector mode, If you like to recover the acquisition geometry for <u>shot</u> points sources, call dialogue box <u>Model</u> > <u>Acquisition</u> Geometry and then select <u>shot</u> points for the parameter <u>Source</u>.

In the group of <u>Shotgather Record</u>, duration of recording and the sample interval are specified in unit of ms (<u>Start</u>, <u>Stop</u>, <u>Step</u>).

5.2 Source wavelet



Select the dominant frequency of the source signal by the parameter <u>Frequency</u>. This parameter has considerable influence on quality of computed gathers and on time step needed for stable wave continuation. Generally, the higher the frequency, the longer the computation time.

• Parameter <u>Wavelet</u> is used for the selection of the signal's form. In addition to these standard wavelet types, you may load any kind of signal from a text file by pressing the button <u>Load</u> from File.

• Parameter Source Mode is used to specify the signal's directionality.

• Parameter $\underline{Surface Mode} - If \underline{invisible}$ is selected, the free-surface related reflection will not appear in the seismic wave field. If \underline{free} is selected, the free-surface related reflection is taken into account in the wavefield.

• The option <u>Use minimal-phase signal</u> – If the option is checked, the amplitude spectrum of the signal will be kept unchanged, but its phase spectrum will be changed to obtain the minimum-phase signal.

• The option <u>Suppress</u> <u>Source</u> <u>SV</u> is for suppressing shear waves. When the source is located closely to the free surface, checking this option can reduce strong surface waves in the shot gather, when <u>Elastic Modeling</u> or <u>Elastic Anisotropic Modeling</u> is used.

5.3 Additional parameters

Some specific parameters associated with various modeling procedures are to be specified. Therefore, the available parameters in the dialogue box <u>Addition</u> differ depending on the selected modeling procedure in the previous step (see Section 5.1).

For the finite difference solution of the wave equation, e.g., Vertical Incidence Modeling, Scalar Modeling, Acoustic Modeling, Elastic Modeling and Elastic Anisotropic Modeling, the dialogue box Addition consists of the following parameters:

Addition	X
Addition Computation Grid Properties Cell (dx, dz) 7.8 m auto Tact (dt) 3.7 ms auto V Generate snapshots Start 0 ms Step 50 ms Generate by every 1 $\stackrel{\bullet}{=}$ source	Threads per process Max Produce time field None GPU GPU F Enable GPU OpenCL (f available)
Attenuation (Quality) Margin 1250 m auto	 Higher Order Approximation (better quality) PML for invisible boundaries (better suppresses reflections in most cases) Components: value range
< <u>B</u> ack	Next > Finish Cancel Help

• <u>Computation Grid Properties</u> are the parameters of the grid size and time step for finite-difference modeling. It is recommended to use default values by having the buttons auto pressed down)

• <u>Generate snapshots</u> – during numerical modeling, a special file <u>Snap.tgr</u> is created, which contains the snapshots of the wavefield. The parameter <u>Start</u> is the time when generation of snapshots starts. The parameter <u>Step</u> (step of discretization) is the time interval between two successive snapshots.

• <u>Generate by every ... source</u> to specify the source interval with which the snapshot is generated.

NOTE: The snapshots file (...Snap.tgr) for each source uses lots of computer memory. Additionally, merging of the snapshots for each source into one single file (this is the last phase of synthetic gather computation) requires significant time. Thus, it is recommended not to generate snapshots if you do not need them or specify larger time interval for generation of snapshots (parameter <u>Step</u>) and omit some sources by parameter <u>Generate by every ...</u> source.

• The option <u>Use attenuation</u> determines whether to take into account the Quality factor during computation if it was specified for a polygon (please see details in the Section 3.2.6)

• <u>Margin</u> is for widening the computation area outside the acquisition aperture.

• <u>Threads per process</u> – Determines the number of cores used during modeling. <u>Max</u> means that all the processor cores are used.

• <u>Produce time field</u> – During the computation of the wavefield, the time field of the incident waves can be generated: <u>First Arrivals</u> for the first arrivals of the incident wave and <u>Maximum Energy</u> for the arrival of the most-energetic incident wave.

• <u>Components: value range</u> – When the model is built by well database (please see details in the Section 3.2.10), the parameters limit the values of velocity and density of the polygons which are obtained from the well logging data by interpolation.

5.3.1 Eikonal Ray Tracing Modeling

For eikonal ray tracing modeling method, the parameter <u>Max. Dip of reflector</u> is added, which limits the slope angle of the reflector. The feature of <u>Snapshot</u> is not supported in case of eikonal ray tracing.

Addition	×	J
Computation Grid Properties Cell (dx, dz) 4.5 m auto Tact (dt) 2.1 ms auto	Threads per process Max Produce time field None	
Eikonal Ray Tracing Options		
Max. Dip of reflector 60 🛨 (in degree	es from a horizonlal axis)	
☐ Ignore anisotropy ☐ Generate converted waves		
Attenuation (Quality)		
Margin 1250 m auto	Components: value range	
< <u>B</u> ack	Next > Finish Cancel Help	

5.3.2 2.5D Elastic Anisotropic Modeling

For 2.5D modeling, the <u>Receiver Lines for Shotgathers</u> group is added in the first <u>General</u> dialogue box, which allows specifying the range and interval of the receiver line in the direction of the crossing line.

General	X
Modeling Procedure 2.5D Elastic	•
Sources to compute	
Source shot points 💌	From #: 1 All Active To #: 40
Shotgahter Record	Additional 3D Acquisition Geometry Parameters
Start 0 ms	Receiver Lines for Shotgathers
Stop 2000 ms auto	From Y 0 m
Step 2 ms	To Y 0 m
	Step dY 0 m 1 lines
Save results to C:\Users\Stefan\Desktop\E	xport_to_seismic_format_test\Browse
< <u>B</u> ack	Next > Finish Cancel Help

If a 2D VSP acquisition geometry was built, then the user can replicate it to a circular VSP survey by selecting VSP radial allocation scheme of sources.

General	
Modeling Procedure 2.5D Elastic	
Sources to compute	
Source shot points -	From #: 1 To #: 201
Shotgahter Record	Additional 3D Acquisition Geometry Parameters
Start 0 ms	VSP radial allocation scheme of sources
Stop 1000 ms auto	From angle 0 deg
Step 1 ms	To angle 360 deg
	Step angle 30 deg 12 shots p/s
	Assume horizontal layered model (faster calculation)
Save results to C:\Users\Stefan\Desktop\Leis	smer model\Modeling-Alex\Job-02\
Edit the task file Do not create new job, lau	nch using existing runtask.ini
< <u>B</u> ack	<u>V</u> ext > Finish Cancel Help

In the dialogue box <u>Addition</u>, the group <u>Y</u> Fourier Transform Spatial <u>Frequency Range (K2)</u> is added. It is specific for implementation of 2.5D modeling which use the spectral decomposition technique in the Y direction where variation of the rock parameters is assumed to be invariant.

Addition	×
Computation Grid Properties Cell (dx, dz) 4.5 m auto	Threads per process Max
Tact (dt) 2.1 ms auto	GPU
Generate snapshots Start 0 ms Step 50 ms Generate by every 1 <u>→</u> source Y offset 0 m	Y Fourier Transform Spatial Frequency Range (K2) From 0 To 0 Number of K2 values per shot 0 Calculate
Anisotropy/ Practuring Attenuation (Quality) True Viscosity Number of relaxation mechanism Margin 1250 m auto	PML for invisible boundaries (better suppresses reflections in most cases) Components: value range
< <u>B</u> ack	Next > Finish Cancel Help

The gathers in the 'A' column are noisy due to insufficient range of spatial frequency (From, To).

The gathers in the 'B' column contain the signal from virtual sources due to insufficient number of spatial frequencies (Number of K2 values per shot).

The gathers in the 'C' column are correct.



It is recommended to adjust these spectral decomposition parameters automatically by pressing the button $\underline{Calculate}$ in the lower part of the same group.

In any case, the 2.5D modeling requires huge amount of computations, just like a

complete 3D case. It is accelerated by effective parallelization, especially by using GPU (NVIDIA CUDA). To decrease the computation time, users can specify shorter time for the parameter <u>Stop</u> in the dialogue box <u>General</u>.

5.4 Gather Calculation

After the modeling method and the relevant parameters are specified, please press the button <u>finish</u> to launch the job and then the <u>Modeling in Progress</u> window should appear to allow users to monitor the job progress.



In the upper part of the <u>Modeling in Progress</u> window, the percentage of computation done for the current source is shown, and the percentage of computation done for the whole job is also shown. On the left, the part of the gather being computed is shown, and on the right, the corresponding wavefield is shown. In the bottom, the log file is echoed as job is running.

If you want to terminate computation, press the Terminate button.

If an error occurs during the computation, the message will be shown in the lower part of the <u>Modeling in Progress</u> window. To check the log messages of a finished job, choose Run > Show Progress Dialog menu command.

After the modeling job is done successfully, the <u>Modeling in Progress</u> window will be closed automatically and then the computed gathers will be displayed in the Tesseral Pro window.



The output files of the modeling will be created in the same folder with the project. In case of elastic isotropic modeling (Elastic Modeling), if the project is **ModelOne.tpa**, the following output files will be generated:

ModelOne+GathEP.sgy	Gather
ModelOne+GathEP.tgr	3-component gather TGR:
	Vertical particle velocity, Horizontal
	particle velocity, Normal stress
ModelOne+SnapEP.tgr	Wavefield snapshots
ModelOne+TimeEP.tgr	Traveltime from the source
ModelOne+WaveEP-1.tgr	Wavelet

Please see the Section 13 for details about outputted gathers in the Tesseral Pro.

5.5 Modeling using cluster and windows network

To use the finite difference methods (except the 2.5D Elastic Anisotropic Modeling) available in the Tesseral Pro to compute the synthetic gathers, it is enough to have a modern PC. For the 2.5D Elastic Anisotropic Modeling, the runtime can vary from several hours to several days, depending on the model size and the selected computation parameters. Due to this fact, it is recommended to use a cluster or a network of PCs to launch the 2.5D Elastic Anisotropic Modeling.

5.5.1 Modeling using a cluster

In Tesseral Pro, the model can be prepared within Tesseral Pro and the job for computation of synthetic gathers can be launched on a cluster. The cluster may work under Windows or Linux (UNIX). The Tesseral Pro package does not work directly with the cluster. It is assumed that the users copy the job and the model to the cluster explicitly, launch the job and copy the computation results back to Tesseral Pro for visualization.

To prepare the job for a cluster, call $\underline{\text{Run} > \text{CLUSTER}}$: Create task. The dialogue box for job preparation is similar to the dialogue box for setting up jobs in the Tesseral Pro (see Section 5). For example, for the project **ModelOne.tpa** with 3 sources, the following files will be generated:

runtask.ini
ModelOne1.tam
ModelOne2.tam
ModelOne3.tam

Here **ModelOne1.tam**, **ModelOne2.tam**..., are the model files associated with each source. "runtask.ini" is the main file where the modeling parameters for the job are saved.

It is recommended to create an empty folder where this job will be created and saved. In this case, the benefit is that users will not need to check whether a file is related to this job or not. The 2.5D computation engine for a cluster may be downloaded from the website http://www.tesseral-geo.com under page "DOWNLOADS". The needed user documentation is in the archive with each program.

5.5.2 Modeling using Windows network

For large computation tasks, Tesseral Pro provides a special utility TesseralFarm. TesseralFarm is a utility complementary to the Tesseral Pro and it is designed to implement cluster functionality in the Windows networks. Compared to the cluster under Linux architecture, the cluster created with TesseralFarm requires far less efforts for preparation and has more flexible topology and sufficient potential for enhancement. After computers are connected to a local network and the program is tuned, the computation tasks can be broken down and allocated to each computer. TesseralFarm gives the possibility to manage computations in separate nodes and to obtain (merge) the common result.

Please see details about the installation and tuning of the TesseralFarm in separate document.

Job launch and job distribution in a Windows network is done in Tesseral Pro by calling Run > NET: Run modeling.

It is possible to get all computers available in the network by using $\underline{Actions} > \underline{Add}$ All Available Servers.

	雛 TesseralF	arm - mod	el.tam						_ 🗆 🗙
	Eile ⊻iew	Actions <u>H</u> e	lp						
	START								
	Server	Comment	% done	Queue	Status	Result files			
	(<local>)</local>			1-9	Ready				
	PC2			10-17	Ready				
	PC1			18-26	Ready				
	1			1					
Comput in the ne	ers availa etwork	ble	Distrit comp	oution uters	s of so n the	ources among network			

Distribution of the job among the nodes (computers) is shown in the column <u>Queue</u>. For modeling, the sources allocated to each node are shown. You may change the number of sources for each node by double-clicking in the list.

When you have selected the nodes, please press <u>START</u> and the program will start copying the files to the nodes (this may happen instantaneously or may take some time, depending on the sizes of files and network speed). Once the copy of files to the nodes will be completed the computations in the nodes will begin. You can monitor the computation in each node by the messages under the column % done.

	😻 Tesserali	arm - moc	lel.tam				_ 🗆 ×
	<u>Eile V</u> iew	Actions <u>H</u> e	lp				
	📽 🔋 📢		STOP				
	Ser∨er	Comment	% done	Queue	Status	Result files	
ſ	✓ (<local>)</local>		30%	1-9	Working	Waiting for files	
l	PC2		43%	10-17	Working	Waiting for files	
l	✔ PC1		31%	18-26	Working	Waiting for files	
			1				
l	•	Perce	entage of col	mputa	tion done in each of	computers	
							NUM //

If you like to terminate the computations in one of the nodes, please right-click that node and select Break calculation.

If you like to terminate computations in all nodes, click STOP.

Once the computations in all the nodes are completed, the computation results are located in the folder, from which the job was launched.

😻 TesseralFarm	n - model.tam				×
<u>File V</u> iew Actio	ns <u>H</u> elp				
😂 🤋 📢	START				
Server Cor	mment % done	Queue	Status	Result files	
♥(<local>) ♥PC2 ♥PC1</local>	100% 100% 100%	1-9 10-17 18-26	Finished joining files Finished calculating Finished calculating	The modeling is finished. The results are merged	
•					
6 2D Ray tracing

STEP 1. Create a new or select an existing model (the command <u>Model > Create</u> <u>Velocity Model (New Frame)</u> or <u>Edit > New Frame > Model</u>). The model must have sources and receivers (<u>Model > Acquisition Geometry</u>).

STEP 2. Select the polygon, for which you would like to run the ray tracing. **STEP 3.** Launch the job by the command Run > 2D Model: Ray Tracing



More information about the ray tracing parameters can be found in the section 6.3. Here is the result of this method:



In Tesseral Pro, the ray tracing calculations can be accumulated by repeating the command $\underline{\text{Run}} > 2D \quad \text{Model}$: Ray Tracing. If the calculation is recalled with the same parameters for the same layer, its results will automatically replace the existing results. By default, the <u>Model</u> Frame shows the result of the last calculation. The ray paths displayed in the <u>Model</u> Frame for the current calculation can be changed by using the command <u>Model ></u> Raypath Data and Visualization Properties. In the same dialogue box, you may see the parameters of the current calculation, change the mode of displaying the rays and delete some of the past calculations.

NOTE: All ray-tracing calculations are saved in the project file (".tpa" file). Please ensure that ray calculation results will not overwhelm the document. Delete the unnecessary calculations by the dialogue box Model > Raypath Data and Visualization Properties.



6.1 Ray-path display in Frame Model

• Show all rays – The ray paths from the current calculation are shown.

• <u>Show Raypath for active source only</u> – The ray paths from the active source are shown. The ray paths from non-active sources are marked in grey color.



• <u>Show rays of region</u> – Display the ray paths from the current calculation whose source, receiver and reflection point are within the selected area. To define the region, in the dialogue box <u>Model > Raypath Data Visualization Properties</u>, please select <u>Show rays of region</u> and then check <u>Select region by mouse</u>. Then select the region of the model for displaying rays by pressing dragging and releasing the left mouse button. The mode of the region selection will be cancelled automatically after the left mouse button is released.



6.2 Ray-path display in gathers

Please load the field gather or the synthetic gathers calculated by the eikonal ray tracing method or finite-difference methods into the <u>Seismic</u> Frame. It is implicitly assumed that this is the gather corresponding to the model, for which the ray-tracing was done. Please use the command <u>Seismic > Highlight Traced Ray Reflections</u> to show the ray paths in the gather.



The command <u>Seismic > Connect Ray Reflection Points</u> changes the mode of displaying reflection times in a gather (lines with captions or dots).

6.3 Ray-tracing parameters

Ray tracing parameters are specified in the <u>Ray Tracing</u> dialogue box, after selecting the command Run > 2D Ray Tracing.

Ray Tracing
Reflecting boundary (polygon) 8 Top
Grid Cell size 4 m auto
✓ Trace real raypaths
Loop Diffraction points
Separator (account the boundary overlapping)
Margin, angle of 10 degree
Hade err, angle of 7 degree
Wave type PP
Every (source) 1 - Every (redever) 1 -
To number 49 Select all sources Select active source
_Model — 🔽 Generate before ray tracing
Grid model file C:\Sheldon\TestingOfTesseralPro\Run\Untitled-PQR.TGR
Time — 🔽 Calculate by eikonal — — — Use Anisotropy —
P-time file C:\Sheldon\TestingOfTesseralPro\Run\Untitled+TimeEKP.T
S-time file C:\Sheldon\TestingOfTesseralPro\Run\Untitled+TimeEKS.T
Default Cancel

Main Parameters

• <u>Reflecting boundary (polygon)</u> is for selecting a polygon and a reflector (top or bottom).

• <u>Grid Cell size</u> is for specifying the grid size. The bigger is the value, the faster is the calculations and the lower is the accuracy of the raypath.

• Margin is the maximum deflection angle.

• <u>Hade err</u>, <u>angle of</u> is the allowed deviation of the reflection angle from the incidence angle (i.e. allowed deviation of the law of reflection).



• <u>Trace real raypaths</u> is for calculating the actual raypath from the source to the reflector and then back to the receivers.



• <u>Separator (account the boundary overlapping)</u> – If the boundary is fragmented by the overlapping polygons, the calculations for each piece of the boundary are done separately for all receivers and sources. and they ray paths for each compartment will be colored differently.

• $\underline{\text{Loop}}$ – Up to 3 reflection raypaths are calculated for each pair of source and receiver.



• Group <u>Sources</u> – Please select the sources for which you would like to run the ray tracing. The parameter <u>Every</u> (receiver) determines the step in receivers for each source.

• Group <u>Time: P-time file</u>, <u>S-time file</u> – For the ray tracing, you can use the files of travel time that were previously calculated by any finite-difference modeling method (the command Run > Run modeling).

• <u>Use Anisotropy</u> – Please check it if you want to take into account the anisotropy during the ray tracing.

NOTE: The anisotropy parameters are specified in the dialogue box for specifying the parameters of the model layers. Please select the command $\underline{Model} > \underline{Edit Polygon}$, and then in the dialogue box <u>Polygon Properties</u>, click the button <u>Anisotropy & Other</u> Properties.

• Group <u>Model</u> – By default, the option <u>Generate before ray tracing</u> is checked because calculation of the model may be long (if the velocity for the model polygons is calculated by well log curves). If the model has not been changed since the last ray tracing or modeling, the new model calculation is not required and you may leave the checkbox <u>Generate before ray tracing</u> unchecked.

• The button $\underline{Default}$ is to set the default parameters and file names automatically.

7 3D Seismic Survey Design and Planning

3D survey design in Tesseral Pro can be done manually or a survey can be loaded from standard SPS-file.

7.1 3D survey

First of all you need to create a frame Map with topographic background taken from picture (see 7.1.1). If you create a 3D survey design manually, you should use the option $\underline{Map/Acquisition}$ geometry to choose the pattern and basic parameters for 3D survey (see 7.1.2). Use $\underline{Map/3D}$ survey modes menu command to adjust your design parameters and layout to match the real topographic map (see 7.1.3).

7.1.1 Load Map using backgroud picture.

Command: Map/Create Map (new frame).

Create new Map 🛛 🗙	
WIZARD	
Load TXT or GRD-surface files >	
Show database WELLS >	
Acquisition Geometry >	
Select background PICTURE >	
Cancel	

In the dialog <u>Create new Map</u>, press <u>Select background PICTURE</u> or <u>Load</u> <u>TXT or GRD-surface files</u> (see section 14 for the latter). Choose the picture file with the desired topographic map. Tesseral Pro supports the following picture formats: BMP, JPEG, TIFF, GEO-TIFF, GEO-JPEG with coordinates in TFW, JGW files.



You need to input coordinates for two base points in the <u>Background Picture</u> dialog to align this picture with the real topographic map. You can move these points manually in the lower part of this dialog using the mouse. For example, when you click mouse and choose <u>Point "2"</u>, the <u>Horizontal</u> and <u>Vertical</u> edit boxes become enabled for inputting applicable coordinates. The same will be true for Point "1".

If the picture coorditate system is different from the project one, specify it using the dialog called by the button <u>Convert</u> COORD.

The result:



NOTE: Please remember that map axis's orientation can be specified in the <u>File/Project Properties</u> dialog:

ſ	Project properties
	Units of Measure Distance m Velocity m/s Density kg/m^3 V
	Select Fields for the Project (for Map Frames)
	[655:35] General (m) [655:35] Gorobcivskoje (ft)
	Coordinate System
	If you change either the axes origination or the selected field set, all maps are removed from the project. You will need to calculate or import them again.
	GeoRuler Parameters
	Reference Point Coordinates :
	Easting or Point (m) U Northing of Point (m) U
	Central Meridian of the Projection (degrees)
	Ellipsoid WGS84 (GPS)
	OK Cancel

© 2019-2021 Tesseral Technologies -*User Documentation*- In Tesseral Pro the background picture for the map cannot be rotated to 90°, but it can be mirrored in relation to vertical/horizontal axis (flipped). Because of that, you put coordinates of base points in <u>Background Picture</u> dialog not as X and Y values, but as a distance along vertical and horizontal axis.

To add more background pictures and/or specify their coordinates select a frame Map by left mouse button click and call the command <u>Map/Edit Frame Properties</u>. In the <u>Map</u> <u>Properties</u> dialog press the <u>Background Picture</u> button in the <u>Background</u> group:

ap Properties			×
Edit top title	Size Width 363 mm	Font	Work area
Edit bottom title	Height 146 mm	Palette Palette Background	Project Properties and Coordinate orientation
Layers			Geographic Coordinate System
Active Layer		\sim	🗹 Draw Ruler
Show Grid (fill color)			Draw Grid Cartesian Coordinate System
✓ Draw Isoline	Font height (%) 90 🚔	Properties	Draw Ruler
\checkmark Show values in the well	Font height (%) 80	Color	Draw Grid
Database wells		Background	
Well Title At collar	~	Show pic	ture Background Picture
🗹 Draw Well Inclinometry	Inclinometry Properties	Show get	o map
Draw Log	Log Properties	Acquisition Ge	ometry
Seismic plan view		Draw	Survey Geometry
Draw Seismic frames plan		Scale : Yes	s 🗸 Source Receiver
Draw sources from seismic	file Load		OK Cancel

In the appeared dialog one can select and setup one or several background pictures:

Background Pictures (Maps/Photos)	×
C:\tmp\2010-05-01\4nic\Sample Contif tif	
C:\tmp\2019-05-01\4pic\Sample Geotintin C:\tmp\2019-05-01\4pic\Sample Jpeg.jpg	
Add Edit Remove Remove all OK Cance	el 🛛

Multiple pictures (usually either 2 or 4) are used at the junction of cards or photos.

If you want to hide the background picture and not show it in frame <u>Map</u>, you should use Frame Map Properties, and uncheck Show Picture.

To remove background picture press <u>Background</u> Picture and then click either <u>Remove</u> or <u>Remove</u> All.

Now you can use the created Map frame for the 3D survey design.

7.1.2 Choose 3D survey design.

Select the Map/Acquisition Geometry menu command.

Acquisition Geometry			_	\times
Type of 3D survey design	3D Survey Layout	Recording Patch	Survey bearings	
	O VSP Azi	muthal	O Marine Flank	:
O Template Repeat	O VSP Rad	dial		
Diagonal	O VSP (1	source)		
O Shot in Brick Pattern	◯ VSP (fo	rm SPS)		
⊖ Cross	VSP Ort	thogonal		
○ Load Survey from SPS- ○ Load Survey from SGY	-files Select	SPS-files > Seg-Y file >	Add to cur geometry	rrent
	ОК	Отмена	рименить С	правка

Tesseral Pro can support different types of 3D survey design.

1) Orthogonal

***	***	•••	••••	••••	•••	***	••••	***	••••	
•••	•••	••••	••••	••••	•••	***	•••	***	••••	

2) Shot in crankshaft pattern



3) Diagonal



- 4) Load survey from SPS-files (see 7.1.8)
- 5) Load from SGY-files (see 7.1.8)
- 6) VSP azimuthal



7) VSP radial



including the "flip-flop" type:

...and several other.

In the <u>3D Survey Layout</u> tab you can specify the increment between Shot and Receiver Lines and their stations.

				_
cquisition Geometry				
Type of 3D survey design	3D Survey Layout	Recording Patch	Survey bearings	
Shots				
Line increment	200 m		.A	
Station increment	50 m		II L	
Peceivers				
Line increment	200 m	Dopth of Docordin	a 2000 m	
Line increment	200	Deput of Recording	g 2000 m	
Station increment	50 m			
	ОК	Отмена Пр	оименить Справн	a

NOTE: the additional parameters right from the first column of increments depend on the survey type.

In the <u>Recording Patch</u> tab you can specify the number of receivers engaged with every shot. In <u>Inline receivers group</u> and <u>Crossline receivers group</u> you can specify the number of receivers nearest to a shot which fall into this group. If you choose the <u>By Distance group you need specify the Radius of the circle</u> which will enclose all receivers around the shot point.

Acquisition Geometry	x	
Type of 3D survey design 3D Survey Layout Recording Patch Survey bearings		
C By group		
Inline receivers group		ว รังดงรังดงวรังดงรัดดงรัดดงรัดดงรัดดงร ัดด งรัดดงรัด ด งรั ด
Crossline receivers group		
By distance Radius of the circle 1000 m		
Use mask		
OK Cancel Apply Hei	Þ	รลู้การสู้จรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้มรรลุ้ม วลับรรล์กรรล์กรรล์กรรล์กรรล์กรรล์กรรล์กรรล์

NOTE: You can design recording patch of any shape using options <u>Remove</u> <u>Receivers from Shot</u> and <u>Add Receivers to Shot</u>. These options can assign receivers to a recording patch. In this case the <u>Recording Patch</u> dialog of the <u>Acquisition Geometry</u> you can click <u>Use mask</u>, and <u>Inline receivers group</u> and <u>Crossline receivers group</u> will be ignored and a newly designed recording patch will be used for the whole survey.

In Survey bearings you can specify the dimensions and direction of 3D survey.

Acq	uisition Geometry									×
T	ype of 3D survey des	ign 3D Su	rvey Layout	Reco	rding F	Patch Sur	vey bearings			
	ORIGIN (0:0):	X beg.	13800		m	Y beg.	22900		m	
	INLINE:	Lenght	6200		m	Azimuth	-4.8		deg	
	CROSSLINE:	Lenght	3000		m	Azimuth	+90	•	deg	
	<u> </u>									
			OK		Cance		Apply		Help	

Result:



NOTE: The coordinates of the 3D survey's Origin Point (X beg., Y beg.), <u>INLINE/CROSSLINE Length</u> and <u>Azimuth</u> can be assigned "visually" in the <u>Map</u> frame using <u>Map/Section Mode command</u>. Draw a profile line using left mouse button (clickdraw-release) and open the <u>Map/Acquisition Geometry</u> dialog. If you are creating a 3D survey for the first time the direction of this survey will coincide with the direction of the line which you have just drawn. If you want to change the dimension or direction of an already created survey then using the mouse you need to select the command <u>Map/3D survey</u> <u>Modes/Moving with rotation</u>. See the instructions below...

7.1.3 Marine surveys

For marine surveys the configuration of the source-receiver geometry can be specified in the Seismic system deployed from the vessel.

Acquisition Geometry				×
Type of 3D survey design	3D Survey Layout	Recording Patch	Survey bearing	ngs
Orthogonal	○ VSP Azi	muthal	Marine Flag	ank
O Template Repeat	O VSP Ra	dial		
	O VSP (1	source)		
O Shot in Brick Pattern	○ VSP (fo	rm SPS)		
⊖ Cross	O VSP Ort	thogonal		
○ Load Survey from SPS ○ Load Survey from SGY	S-files Select	SPS-files > Seg-Y file >	Add to geome	current try
	ОК	Отмена	рименить	Справка
Acquisition Geometry				×
Type of 3D survey design	3D Survey Layout	Recording Patch	Survey bearin	gs
Shots				
Line increment	200 m	Distance between	shots 50	
Station increment	<mark>50</mark> m			
Receivers				
Distance between cal	200 m	Seismic system	n deployed from	n the
Distance between cal Station increment	200 m 50 m	Seismic system	n deployed from vessel	n the
Distance between cal Station increment	200 m 50 m	Seismic system	n deployed fror vessel	n the

The parameter <u>Distance between shots</u> is used to specify the distance between the two sources (water guns) of the "flip-flop" marine surveys. If the only water gun is used, set the distance to 0.

The <u>Free Cable</u> option allows the user to maintain the recording patch stationary for all sources along the Inline direction. The <u>Frequency of Moving</u> specifies the frequency of 2 means that the recording patch would be displaced for every second source in the Crossline direction. The <u>Moving Step</u> is the displacement step of the recording patch along the Crossline direction for each consecutive source along the same direction. So a <u>Moving Step</u> of 200 would mean that the recording patch would be displaced 200m for every source (i.e. if the <u>Frequency of Moving=1</u>) along the Crossline direction. <u>The Start Position</u> specifies the starting position of the recording patch (i.e. the position of its lower left hand corner for a zero azimuth). So for example a <u>Starting Position</u> for <u>Inline=0</u> and <u>Crossline=0</u> means that the starting position of the recording patch would be at the lowermost left hand corner of the 3D survey, as shown below.

Seismic system deployed from the	vessel	×
Seismic cables		
Number of cables	4	
Distance between cables	200	m
Cable length	500	m
Step between hydrophones	50	m
Free Cable		
Frequency of Moving	1	
Moving Step	50	m
Start Position: Alig	in Centre)
Inline: 0 m Crossli	ine: 0	m
Source (air-gun) position		
Distance from the source to cables	50	m
ОК	Car	ncel

Acquisition Geometry							
	Type of 3D survey design		3D Survey Layout	Recording Patch		Survey bearings	
	ORIGIN (0:0):	X beg	g. 1180.9	m	Y beg.	1106.3	m
	INLINE:	Lengt	th 1800	m	Azimuth	ol	deg
	CROSSLINE:	Lengt	th 2100	m	Azimuth	+90 •	deg
OK Cancel Apply Help							



7.1.4 Move and Rotate 3D survey.

The <u>Map > 3D</u> survey Modes > Moving with rotation command is used to correct the 3D survey positioning on a map. Use left mouse button (click- drag-release).



Another mode of the survey move is its vertical projection on the day surface, a selected horizon or a plane of the specified depth. The $\underline{Map} > \underline{Set Shot/Receiver Depths}$ command is used to implement the operation:

Set Shots/Receivers Depth ×				
	✓ Shots	Receivers		
• Fixed depths :	0	0		
O Depth from map :	n	\sim		
Positions in Plan				
Station projecting	g (fixed XY)	In the station chaining (XY can change)		
	OK	Cancel		

There are two methods of the vertical shift: the <u>station projection</u> preserves horizontal coordinates of the stations when the <u>station chaining</u> limits max distance between the neighbor single line stations along the target surface and hence may shift the stations along the line.

7.1.5 Edit Shot and Receiver Stations.

Option <u>Map/3D</u> survey <u>Modes/Hide</u> is used to hide not needed shots or/and receivers from a 3D survey.

Shots / Receivers : Hide ×				
Shots Receivers				
Select by Eraser Radius 15				
O Select Group by Polygon				
○ Select by Limit X ∨ > ∨ 703499.25				
○ Select outside of [ромб.txt] ∨				
○ Select inside of [ромб.txt] ∨				
◯ Select All				
Apply Cancel				

The user has the option to hide shots and receivers by <u>Eraser</u> (where the eraser is in the form of a circle with a specified <u>Radius</u>) by pressing the left mouse button, holding it and selecting the area which is to be hidden. Hidden shots/receivers will not take part in the following 3D survey design. Hidden shots and receivers will be not shown on the Map frame in most the edit modes. In some modes they are by default shown grayed and crossed. (The icon color, size and form can be fitted in the frame parameters dialog.)

For <u>Select Group by Polygon</u> a polygon needs to be drawn and all the shots and receivers inside it will be hidden. In order to implement it simply use the left click mouse button to draw a polygon around a group of shots and receivers. To start over the drawing click the right mouse button. Once the polygon has been drawn, double click the left mouse button and all the shots and receivers in the polygon will be hidden.

Similar options <u>Select outside of...</u> and <u>Select inside of...</u> use predefined polygons from the selected static layer.



You can also hide shots and receivers by specifying a limit along the X and/or Y axis:



Use <u>Select All</u> to hide all shots and receivers.

If you want to bring hidden shots/receivers back into survey you need to use option Map/3D survey Modes/Show. The same methods for showing shots/receivers apply.



NOTE: If you want to use options <u>Hide/Show</u> separately for shots and receivers (for example, to hide a group of shots, but to leave receivers there), you need to check <u>Map/Show</u> <u>Shots</u> or <u>Map/Show</u> <u>Receivers</u> respectively. As a result shots or receivers will not be shown in the Map frame, and editing will be possible only for shown elements (shots or receivers).

In order to increase or decrease the editing precision use the scaling option in the View/Zoom command.



By default the icons of sources and receivers (together called stations) are scaled by zoom like other graphic elements. For better resolution, however, it is sometimes useful either completely cancel the station scaling or significantly decrease its relative speed. It is done in the frame parameter dialog:

Map Properties			×
Edit top title Edit bottom title	Size Width 153 mm Height 55 mm	Font Palette Ø Background	Work area Project Properties and Coordinate orientation
Layers Active Layer		~	Geographic Coordinate System
 ✓ Show Grid (fill color) ✓ Draw Isoline ✓ Show values in the well 	Font height (%) 90 🔶 Font height (%) 80 🜩	Properties Color	 ✓ Draw Grid Cartesian Coordinate System ✓ Draw Ruler ✓ Draw Grid
Database wells Well Title At collar	✓ Inclinometry Properties	Background	ure Background Picture
Draw Log	Log Properties	Acquisition Geo	Survey Geometry
Seismic plan view	ile Load	Scale Yes Scale No	Source Receiver

Here one also can setup the station icons in the dialogs activated by the buttons <u>Source</u> and <u>Receiver</u>:

Source Point Visualization Options X	State :	Active \checkmark
State : Active		Active Inactive Moved Hidden
100% : - 200% : -		
Symbol : triangle down		
Line color Line width :	Symbol :	triangle down 🗸
Internal color Radius : 3		rectangle circle rhomb
Save as default OK Cancel		triangle up triangle down

The button <u>Save as default</u> remembers the station settings for further projects.

Below is a sample of alternative design created by the described tools.

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7.1.6 Change Direction for Shot and Receiver Lines

Using the menu command <u>Map/3D survey Modes/Moving Shot and</u> <u>Receiver lines</u> you can change the shape for Shot and Receiver Lines in order to adjust them to real land topography. In order to do that 4 types of displacements have been implemented: <u>Cable Move</u> used if you want to reposition shot/receiver lines in a cable fashion (such as orienting the shot/receiver line along a different azimuth), <u>Point Selection</u> to displace individual shot(s)/receiver(s), <u>Line Selection</u> to displace the whole line to a different position while preserving its geometry, and <u>Polygon Selection</u> whereby you draw a polygon around a group of shots/receivers and displace the whole group to a different position.

Moving Shots / Receivers ×					
Selection Type Shots Receivers Cable Point Line Polygor					
Change Src/Rec (Only VSP)					
Point;	Action:	Type:			
\sim	\sim	\sim			
From	To (y):	Step (z);			
0	0	0			
	We	ll: ~			
Select	Apply	Cancel			

The following example illustrates a <u>Cable Move</u> and the same principle applies to <u>Point Selection and Line Selection</u>.

To show this example without obstacles, the background picture has been hidden (in dialog <u>Frame Map Properties</u> we clicked off <u>Show Picture</u>), Receivers were hidden as well (clicked off Map/Show Receivers).



After the creation of the first 3D survey each Shot/Receiver Line has two "anchor" points which tie a line to its plane position. So you can:

- 1. Change the "anchor" position using the left mouse button (click-pull-release);
- 2. Remove an "anchor" by double clicking of the left mouse button;
- 3. Add a new "anchor" click the left mouse button at any shot point.

The same can be applied for Receiver Lines:



Shot and Receiver Lines can be moved independently or together:

For <u>Polygon Selection</u> simply use the left click mouse button to draw a polygon around a group of shots and/or receivers. To start over the drawing click the right mouse button. Once the polygon has been drawn, double click the left mouse button and drag the automatically formed rectangle to the desired location using the right mouse button.





7.1.6.1 Station coordinates and numbers

Use the context menu command <u>Shot/Receiver</u> <u>Coordinates</u> in the Survey Line mode to show coordinates of a station selected by a left mouse button click:



The dialog is floating (non-modal) and you don't need to close it to see coordinates of another station. The coordinates can be changed and remembered by the button <u>Set</u>. The change will result in moving the source or receiver in the specified coordinates.

<u>Position</u> and <u>Line</u> are formal numbers not dependent on the position mark/label. The position number is the serial number of the station in the survey. It is not changed when the station is moved or some stations are hidden. The same is true for the line numbers. The station number according to marks/labels is shown as <u>Inline ID</u> and <u>XLine ID</u>. The numbers -1 you see in the above dialog mean "not defined". They are defined from the very beginning for the surveys imported from SPS or SEGY files. Else they are defined when the survey is exported as SPS.

The dialog does not disappear if you switch to another edit mode such as Zoom mode to increase the survey resolution. Yet it stops working until the Survey Line mode is restored by $\underline{Map} > 3D$ Survey Edit Modes > Moving Shot and Receiver Lines or the correspondent toolbar button.
7.1.7 3D recording patch design.

First of all you need to specify a recording patch for each shot in <u>Map/Acquisition</u> <u>Geometry</u> dialog in the <u>Recording Patch</u> tab (see 7.1.2). <u>Inline receivers</u> <u>group</u> and <u>Crossline receivers</u> group parameters identify the number of nearest receivers which will be assigned to the current source.

You can change a shape of recording patch using mask and apply it for the entire survey. First of all you need to choose a source in the middle of the survey. In <u>Map/3D</u> <u>survey</u> <u>Modes/View Relation</u> menu command click the selected shot point. The chosen Shot will be highlighted with a red dot, the rest of shot points will be shown as grey dots. Receiver points associated with the chosen source will be colored in blue and the rest receivers will be grey:

<mark>≓</mark> m	ap -	Tes	seral	Pro																										_ 🗆 🗙
Eile	Da	tabas	e į	≣dit	<u>V</u> iet	W	Mod	el	М₫р	<u>S</u>	eismi	с 3	D Vie	ew	<u>R</u> un	He	elp													
	D	2		5	<u></u>	ŧ	ξŞ	\square	Ø	₽ ₽		; =	*⁄4			i 📉		₹.	Q	.⊕	200	%		•	Þ		\?			
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Synthe	etic s	eism	ograr	ns cr	eating	g:	ST	EP 1	: Crea	ate V	'elocit	y Mod	el >		STEP	° 2: A	cquis	sition	Geon	netry	>	ST	EP 3:	Run n	nodelir	ng >			Hide	
inline:	63,	cross	line:	9,[3	100.0	0,160	0.0]																X=:	16373	8.5		Y=2	2843.5	

You can add or remove receivers around this shot point by using <u>Map/3D</u> survey <u>Modes/Remove Receivers from Shot</u> and <u>Map/3D</u> survey <u>Modes/Add</u> <u>Receivers to Shot</u> commands. These two commands behave similarly to the <u>Hide/Show</u> command (click-drag-release).

Example:

🚰 map - TesseralPro	
Ele Database Edit View Model Map Seismic 3D View Run Help	
▶ □ 🛎 🖬 🕰 🖄 💯 🖉 📴 🎬 🚈 🖄 🔛 🔣 🔍 🔍 🔍 🥄 💷 💴	
≠ ≠ ⊠ ♀ ≠ ≠ ≠ ≠ ≠ ≠ = • ⊂ = • ⊂ = = □ = = □ = = = □ = =	
P B m A	
	 •
Synthetic seismograms creating: STEP 1: Create Velocity Model > STEP 2: Acquisition Geometry > STEP 3: Run modeling > Hide	
inline: 47, crossline: 10, [2300.0,1800.0]	

Now you can pick any source in <u>Map/3D survey Modes/View Relation</u> and the group of receivers allocated for that source will have identical shape. At the same time the <u>Acquisition Geometry</u> dialog in the <u>Recording Patch</u> tab the "Use mask" checkbox will be automatically enabled:

Acquisition Geo	metry	6		×
Type of 3D surv	vey design 3D Survey Layout	Recording Patch	Survey bearings	
	C By group			
	Inline receivers group	20 ÷		
	Crossline receivers group	20 📫		
	By distance Radius of the circle	000 m		
(Use mask			
	ок	Cancel	Apply H	lelp

In other words, the receiver patch is specified by the mask which has been shaped manually but not by parameters Inline (Crossline) receivers group.

7.1.8 Load survey from SPS-files.

Here is another useful way to create 3D survey using standard SPS-format. You can use the same command Map/Acquisition Geometry.

Acquisition Geometry Type	— ×
WIZARD	
Orthogonal >	••••
Template Repeat >	
Shot in brick pattern >	Ŧ
Diagonal >	Z
Cross >	.
VSP azimuthal >	k
VSP radial >	
Marine Flank >	·
From SPS-file >	
From SGY-file >	
C	ancel

Select Load survey from SPS-files and press the Select SPS-files> button.

In the next dialog load the SPS-files for shots, receivers and their relation file. As you can see above Tesseral Pro supports the importation of various SPS file formats.

Load survey specification	on from files	—	۲.
Survey File Format:	auto detection auto detection SPS 1		
File of Source D:\People\VN\2.s01	SPS 2 SEG SP KML TXT Shape P1/90 P1/11		
File of Receiv	ers		
D:\People\VN\2.r01			
File of Elevent	Shot-Receiver Relation		
Sea observations		🗌 Fast load	
	< Back Next >	Cancel Help	

Check <u>Sea</u> observations if the SPS describes a marine (offshore) survey.

Press $\underline{Next} >$ and the next dialog with the 3D survey loaded from these SPS-files will be displayed.



You need to input coordinates for the ORIGIN point and the INLINE Length and Azimuth in this dialog. This line is needed to make it easier to move and rotate the 3D survey which has been loaded from SPS files. It is recommended to use mouse to draw the line on the map (click--drag-release). You do not have to be precise with line drawing.

You can zoom in this picture by pressing the 200m map button to view it at a bigger scale.

There is also an ability to specify the SPS coordinate system different from the project one. It is implemented by pressing the button <u>COORD</u> <u>Convert</u>:

Coordinate co	nversion	×						
Coordina	ate conversion To system							
- Input cod	Input coord system							
⊚ XY	⊖ grad							
Input Pa	Input Parameters of Geographic Coordinate System							
Referenc	e Point Coordinates :							
East of G	Preenwich 0 North of Equator 0							
Central M	Ieridian of the Projection 0							
Ellipsoid	WGS84 (GPS) V							
	WGS84 (GPS) NAD83 (GRS 80) NAD27 (Clarke 1866) ETRS89 SK-42 (Krasovsky ellipsoid) PZ-90 (GLONASS)							
	GSK-2011							

The dialog is similar to the one used in \underline{File} / $\underline{Project}$ $\underline{Properties}$ to specify the project coordinate system.

As soon as you finish loading the SPS-files, you will be prompted to <u>Acquisition</u> <u>Geometry</u> dialog.

The <u>3D</u> survey Layout and <u>Recording Patch</u> tabs will not be used when you proceed with the <u>Load survey from SPS-files</u> option. In the <u>Survey bearings</u> tab the dimension parameters will be ignored but the 3D survey geographical parameters are necessary:

Acq	uisition Geometry	,						×
T	ype of 3D survey des	sign 3D Su	rvey Layout	Recording F	Patch Sur	vey bearings		
	ORIGIN (0:0):	X beg.	1033690	m	Y beg.	1346890	m	
	INLINE:	Lenght	18588	m	Azimuth	8.8	deg	
	CROSSLINE:	Lenght	11954	m	Azimuth	-90	▼ deg	
				· · ·				
		_	OK	Cance		<u>A</u> pply	Help	

Result:



You can edit survey loaded from SPS-files using the commands Moving with rotation, Hide, Show:



7.1.9 Load survey from SGY-files.

There is also the option of loading the seismic survey from synthetic seismogram in SGY format.

Type of 3D survey design	3D Survey Layout	Recording Patch	Survey bearings	
Orthogonal				
Shot in brick pattern				
Diagonal				
VSP azimuthal				
VSP radial				
Load survey from SPS	G-files Select	SPS-files >		
Load survey from SGY	(-files Select	Seg-Y file >		
	ОК	Cancel	Apply	Help

Select Load survey from SGY-files and press the Select SGY-files>

button.



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7.1.10 3D survey export to SPS-files.

The 3D survey created in the <u>Map</u> frame can be exported into standard SPS format. To do this use the <u>Map>Export to SPS</u> menu command. Select a source file name, and the receiver and relation files will be created automatically. As the result you will have three SPS files:

S01 – source; R01 – receivers;

X01 – relation file.

Save Survey to Files	×							
Output file path :								
C:\temp\2021-09-15\sps\test02.s01								
SOURCE Numbers in the Outp	out Files							
Apply next numbering :	O Use imported numbers							
Line Numbers	Station Numbers							
start : 2001	O end-to-end serial numbers							
	inline numbers:							
step : 40	start : 101 step : 10							
RECEIVER Numbers in the Ou	tput Files							
Apply next numbering :	OUse imported numbers							
Line Numbers	Station Numbers							
start · 101	O end-to-end serial numbers							
	inline numbers:							
step: 40	start : 2001 step : 10							
	OK Cancel							

Furthermore, it is possible to assign inline/crossline numbers (different from the standard n=1, 2, 3, 4, 5...) to the shots and receivers in the exported SPS file. In order to do it, select Apply next numbering for sources and/or receivers. Then specify the Line Numbers and the Station Numbers separately for sources and receivers. Set the values which correspond to each other, so that if a source and a receiver are located in the same position, the shot line number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number is the same as the receiver station number and the shot station number and the shot station number is the same as the receiver station number and the shot station number and the shot station number as the receiver statice station number as the receiver station number as the

7.1.11 3D survey export to KML-file.

The 3D survey created in the <u>Map</u> frame can be exported into standard KML format, which is the format used for displaying objects used by Google Maps. To do this, please use the Map/Export 3D Survey to KML menu command.

SPS File Save	×
File name Test-1	
Parameters of Geographic Coordinate System	
Ellipsoid WGS84 (GPS) -	
Zone 2 (from 1 to 60)	
Reference Point Coordinates :	
East of Greenwich (m) 0 North of	Equator (m)
Central Meridian of the Projection (degrees)	0
6	OK Cancel

Choose a name for the output KML files, the reference <u>Ellipsoid</u>, as well as the zone number. As the result 2 KML files will be generated:

Sources.kmz and Receivers.kmz;

7.1.12 Manage Static Layers.

In the map frame it is also possible to import static layers (i.e. spot boundaries) strictly for visual purposes. The importation can be done from text file using a simple format: coordinates X and Y, then the line number (as shown below). As well static layers are loaded from shapefiles and DXF (Autocad) format files.

🧾 sta	atic lay	yer-2.txt -	Notepa	ad
<u>F</u> ile	Edit	F <u>o</u> rmat	View	<u>H</u> elp
50		50	1	
100		100	1	
150		150	1	
200		200	1	
250		250	1	
300		300	1	
350		350	+	
400		400	+	
1500		500	1	
550		550	÷	
600		600	î	
650		650	ĩ	
700		700	ī	
750		750	1	
800		800	1	
850		850	1	
900		900	1	
950		950	1	
1000		1000	1	
1050		1050	1	
1100		1100	1	
1150		1120	T	

In order upload a Static Layer select <u>Map > Manage Static Layers > From</u> <u>File</u>. The program shows dialog which allows one to specify the static layer coordinate system if it is different from the one of the project (to do it check <u>Coordinate conversion To</u> system and specify other coordinate system parameters of the imported file):

Coordinate conversion	Х
Coordinate conversion To system	
● XY ○ GRAD	
Input Parameters of Geographic Coordinate System	
Reference Point Coordinates :	
East of Greenwich 0 North of Equator 0	
Central Meridian of the Projection 0	
Ellipsoid WGS84 (GPS) V	
ОК	

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Static Layers		
Loads Static Layers:	<u>N</u> ame	<u>R</u> eload
	From <u>Fi</u> le	
	Delete	Close
Isolines Properties Lines Width: 5	Example	

After importing the static layer you can select View and edit the properties of the line.

You can also rename it (using <u>Name</u>), add an additional static layer (<u>From File...</u>) or delete any of them (by selection in the list and using <u>Delete</u>).

The button <u>Info</u> shows the area covered by the selected static layer:

Static Laye	rs Info	×
[Settl	ements.shp]	
Xmin	11977620]
Xmax	12009904]
Ymin	-5658239.5]
Ymax	-5629376]
≤	t to Work Area	
	E	OK Cancel

If before <u>OK</u> one checked <u>Set to Work Area</u> then after exiting the Manage Static Layer dialog the map area will be changed by the static layer rectangle.

Once done, press \underline{Close} and click mouse in the map frame. The new/edited static layers will appear in your map.

7.2 Coordinate Reference Systems Options

Please note that multiple coordinate reference systems are available in the frame <u>Map</u>, and they are based on the following ellipsoids: WGS-84 (GPS), NAD-83 (GRS), NAD-27 (Clarke 1866), ETRS-89, SK-42 (Krasovsky), PZ-90 (GLONASS), GSK-2011.

In order for the chosen reference coordinate system to be displayed, it is necessary in the Map>Map Frame Properties>Project properties... to set non-zero coordinates for Easting and Northing of Point (i.e. upper right hand corner of the map) for the chosen Ellipsoid. And also to set a value for the Central Meridian of the Projection (degrees) of the ellipsoid, which is conventionally set to zero.

Project properties	×
Units of Measure Distance m Velocity m/s Density kg/m^3 Velocity	
Select Fields for the Project (for Map Frames)	
Coordinate System]
If you change either the axes orientation or the selected field set, all maps are removed from the project. You will need to calculate or import them again.	
GeoRuler Parameters	
Reference Point Coordinates :	
Easting of Point (m) 0 Northing of Point (m) 0	
Central Meridian of the Projection (degrees)	
Ellipsoid WGS84 (GPS)	
Cancel	1

7.3 Survey planning

7.3.1 Fold Map menu and toolbar.

The planning can be accesed in one of two ways:

1) In the tab manu Map => Fold Map



2) In the quick access toolbar



The following attributes can be displayed for any 3D seismic survey:



Fold Calculation Properties



- Displaying all bins by selecting Show Bins Grid

Displaying the fold by selecting Show Fold Map

selecting Show Offset Distribution Map

- \bigcirc
- J



<u> %</u>

- Displaying the azimuth distribution for every bin by selecting Show Azimuth Distribution Map

Displaying the offset distribution histogram for every bin by

- Setting the display mode for the map by selecting Fold Display Options
- Displaying the survey bin statistics by selecting <u>Show Bins Grid</u> <u>Statistics</u>
- Displaying the information for a particular bin by selecting <u>Show</u> <u>Selected Bin Information</u>



- Showing graphical statistics for the fold map by selecting <u>Show</u> <u>Plot Statistics</u>



Fold Calculation Properties	
Bin Size	Recording Patch
Inline Bin Size 25	Relations from SPS-File
Crossline Bin Size 25	By Group
Inline Bin Count 40	Stations Count 20
Crossline Bin Count 40	Line Count 5
	By Distance
Auto Fit	Circle Radius 500
Extent	Limits
Left 1000 Right	From To Offset 0 559.01696
0	Azimuth 0 1359
Bottom	Make Offset/Azimuth Limits Exclusive
All Mouse Selection	n
	OK Cancel

7.3.2 Fold Calculation Properties

The dialog is divided into four parts:

First <u>Bin Size</u>, where you can adjust the size of the grid for calculation. There are three ways to do it: the first - to set the length (<u>Crossline Bin Size</u>) and the width (<u>Inline Bin Size</u>) of the bin, the second - set the number of bins in the X (<u>Inline Bin Count</u>) and Y (<u>Crossline Bin Count</u>) direction of the planning area and the third - automatic calculation (<u>Auto Fit</u>). In this case the length of the bin is equal to half the distance between the receivers and the width equals half the distance between the sources.

Second, using <u>Extent</u>, you can set the scope of the calculation, i.e. determine which sources and receivers will not be included in the calculation. This can be set in three ways: to fill in the appropriate fields by clicking (<u>All</u>) - to select the entire field, press the button (<u>Mouse Selection</u>) in order to select the area manually, after which the dialog box temporarily closes in order to allow the user to select the boundaries with the mouse.

The image below, shows a selected region by Mouse Selection:



The corresponding fields displays the coordinates of the selected area:

E	dent		
		Тор	
	Left	841.38842	Right
	103.25131		859.84179
		161.24780	
		Bottom	
	All	Mo	use Selection

Below is the calculated **Fold Map** within the boundaries of the selected area:



The third part of the dialog is the <u>Recording Patch</u>. It contains three different types of source-receiver relationships. The first one is (<u>Relations from SPS-File</u>) —which preserves the grouping from the SPS file, provided that the survey was loaded from SPS file.

Recording Patch		
Relations from SPS	S-File	
By Group		
Stations Count	30	* *
Line Count	10	*
By Distance		
Circle Radius	500	

The second method (<u>By Group</u>) - set the number of receivers per line (<u>Stations</u> <u>Count</u>) and the number of lines (<u>Line Count</u>). The above 30/10 scheme produces the following image:



The third method ($\underline{By \ Distance}$) - which assigns receivers for every source within a specified Circle Radius





The above 500m Circle Radius produces the following image:

The fourth part of the dialogue is the <u>Limits</u> - with which you can limit the <u>Offset</u> and <u>Azimuth</u> for source-receiver pairs that are included in the fold calculation. If the box (<u>Make</u> <u>Offset</u> / Azimuth Limits Exclusive) is not enabled then only sources/receiver pairs <u>From <= Offset</u> / Azimuth <= To will take part in the fold calculation. If enabled, then only source/receiver pairs From> Offset / Azimuth> To will be included.

7.3.3 Fold Display Options



Fold Display Option - Dialog for setting the display mode for the calculated attributes (Fold, Offset and Azimuth).

For Fold Map there are different types of displays: Color and Value – Fills the bins with the appropriate colour from the colour bar and also displays their values.

4	-	6	4	4		6	4	4	-	6	4	4		6	4	
4	6	6	4	4	6	6	4	4	6	б	4	4	6	6	4	
6	\diamond	9	•	6	\diamond	9	•	6	\diamond	9	•	б	\diamond	9	•	
6	9	9	6	6	9	9	6	6	9	9	6	6	9	9	6	
6	9	9	6	6	9	9	6	6	9	9	6	6	9	9	6	
4	6	6	4	4	6	б	4	4	6	6	4	4	6	6	4	
4	•	6	4	4	•	6	4	4	•	6	4	4	•	6	4	
4	6	6	4	4	6	6	4	4	6	6	4	4	6	6	4	
4	•	6	4	4	•	6	4	4	•	6	4	4	•	6	4	
6	9	9	6	6	9	9	6	6	9	9	6	6	9	9	6	

Only Colour: Just the colour is displayed



Only Value – Just the value is displayed.

	,	, in the second	Ū	-	-			-	-	0	Ū	-	-	Ŭ	0
4	4	-	6	4	4	-	6	4	4	-	6	4	4	•	6
4	4	6	6	4	4	6	6	4	4	6	6	4	4	6	6
¢	6	•	9	•	6	•	9	•	6	•	9	•	6	•	9
6	6	9	9	6	6	9	9	б	6	9	9	6	6	9	9
6	6	9	9	6	б	9	9	6	6	9	9	6	6	9	9
4	4	6	6	4	4	6	6	4	4	6	6	4	4	6	6
4	4	-	6	4	4	-	6	4	4	•	6	4	4	-	6
4	4	6	6	4	4	6	6	4	4	6	6	4	4	6	6
4	4	•	6	4	4	-	6	4	4	•	6	4	4	ę	6
6	6	9	9	6	6	9	9	6	6	9	9	6	6	9	9

For Offset Map the following display options are available:

<u>No Color</u> – Colorless scale. The x-axis of the histogram corresponds to the inline bin direction. The scale ranges from zero offset on the left edge of the bin to max offset on the right edge of the bin. The y-axis corresponds to the offset (the maximum offset occupies almost the entire height of the bin, and the minimum offset has height close to zero). Gaps between the lines represent a discontinuous offset distribution.

					. [
		, 1		, 1					
		Ш						Ш	
							•		

© 2019-2021 Tesseral Technologies -*User Documentation*- Color - Displays the «Redundancy», i.e. the number of times each offset falls into the same bin. A single offset has a colour corresponding to redundancy of zero. For more than 1 offset a color is assigned to it according to the redundancy colour bar.



<u>Min Offset</u> - Fill the bins with the colour corresponding to the minimum offset.
 <u>Max Offset</u> - Fill the bins with the colour corresponding to the mean offset.
 <u>Median Offset</u> - Fill the bins with the colour corresponding to the median offset.
 <u>Offset</u> Range - Fill the bins with the colour corresponding to the median offset.

Largest Gap – This option displays a color plot of the largest offset difference between any consecutive offsets in each bin.

Offset Variability (Coefficient of Variation): This plot calculation is a relative dispersion measurement in each bin. This will calculate the standard deviation of the gaps in the offset range and divides the answer by the mean gap. This calculation can only produce a value for bins with at least 3 fold. Normalization is no longer performed. The lower the values in the color scale, the better the offset variability The formula for the calculation is as follows.

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}}$$

s= standard deviation of the offset gaps, formula shown below.

x=offset gap (difference between consecutive offsets in a single bin)

n=number of offset gaps (15 fold bins have 14 gaps)

© 2019-2021 Tesseral Technologies -User DocumentationThe offset variability is then calculated as: Offset Variability = s / mean of x (per bin) For <u>Azimuth Map</u> the following display options are available:

No Color – Colorless scale. Showing "spiders", i.e. the distribution of azimuth directions of source-receiver pairs that fall in each bin. "Spider limb" length depends on the offset.

_																					
	¥	¥	∳	X	¥	∦	∳	X	∦	¥	*	X	¥	¥	∳	X	¥	¥	∳	¥	¥
	¥	¥	Å	X	∦	¥	Å	X	∦	¥	X	X	¥	¥	×	X	¥	¥	Å	X	∦
	∦	X	X	X	∦	X	Å	¥	∦	X	X	K	∦	煮	X	¥	∦	X	X	¥	¥
	*	ж	×	X	ж	Ж	×	k	ж	Ж	X	k	¥	Ж	X	k	¥	ж	×	k	ж
	Ж	ж	Х	χ	Ж	ж	Х	Х	Ж	ж	X	χ	ж	ж	X	χ	ж	ж	X	χ	ж
	Ж	Х	χ	χ	Ж	X	χ	χ	Ж	X	χ	χ	ж	X	χ	X	Ж	X	χ	χ	Ж
	*	х	λ	λ	*	X	λ	λ	*	λ	Ă	λ	*	λ	Ă	λ	X	ж	Ă	λ	*
	¥	¥	Å	X	∦	¥	Å	¥	¥	¥	4	¥	¥	¥	X	¥	¥	∦	X	¥	¥
	¥	¥	*	Å	¥	¥	*	X	¥	¥	*	X	¥	¥	*	X	¥	¥	*	X	¥
_	¥	X	X	X	¥	X	X	X	¥	X	X	X	¥	X	X	X	¥	¥	X	X	¥
	.ν		· ·				,		.ν		,				,		. 1/		,		

<u>Color</u> - Displays the «Redundancy», i.e. the number of times each azimuth falls into the same bin. A single azimuth has a colour corresponding to a redundancy of zero. For more than 1 azimuth a color is assigned to the "spider limb" according to the redundancy colour bar.

\times		\times		\times		\times		\times
\times	×	\times	\times	×	\times	\times	X	×
\times		${\times}$	\times	\bigstar	\times	\times	${\not \rightarrow}$	${\star}$
\times	×	\rightarrow	\rightarrow	\times	\times	\times	×	×
×		×	×	×	×	×	\times	×

<u>Circle Plot</u> - Concentric circles correspond to offset ranges, and the offset increases with increasing radius. To change the distance between circles use the - <u>Line Increment</u> in the field - in the **Offset** tab.





Offset to Azimuth – The midpoint locations for every bin are shown across an Offset vs Azimuth grid. The offset is plotted on the axis X axis (ranging from min to max across each individual bin), while the azimuth is plotted on Y-axis ranging from 0° to 360°, across each individual bin. To change the offset increments change the <u>Line</u> <u>Increments</u> parameters in the <u>Fold Display Option</u> window. Each midpoint is indicated by an asterisk at its corresponding position across the Offset vs Azimuth



<u>Trace Azimuth</u> – Filling the bins with color corresponding to azimuth colour bar, meeting the criteria restrictions specified in the - <u>Line Increment</u> tab for **Offset**. In other words, the **Azimuth** is displayed as a function of the first trace greater than or equal to the specified **Offset**.

7.3.4 Bin Grid Statistic

<u>Bins Grid Statistics</u> - contains statistical information on sources/receivers, surface area and bins. It is possible to calculate the area for a particular region of interest in two ways:

1) Specify the fold range in $\underline{\text{Min Fold}}$ and $\underline{\text{Max Fold}}$, and the total area for the bins within the $\underline{\text{Min-Max fold}}$ interval will be calculated. Reset button resets the value for the Min Fold and Max Fold.

	Arca		
	Min Fold:	5	
	Max Fold:	9	
	Min-Max Areal:	0.51 sq.km	
		Reset	
ey Statistics			
hot Information		Receiver Information	
Shot Lines:	6	Receiver Lines:	6
Total Shot Point:	126	Total Receivers:	126
Live Shot Point:	126	Active Receivers:	126
Unused Shot Point	t: 0	Unused Receiver:	0
Shot Spacing:	50.00 m	Receiver Spacing:	50.00 m
Line Spacing:	200.00 m	Line Spacing:	200.00 m
Total Lenght:	6.05 sq.km	Total Lenght:	6.05 sq.km
Shot Point Density	r: 126.00 /sq.km	Receiver Density:	126.00 /sq.kn
urvey Information			
Inline Extent:	1000.00 m	Mouse Selected Polig	jon:
Crossline Extent:	1000.00 m	Area:	0.00 sq.km
Areal Extent:	1.00 sq.km	Mouse Se	election
ins			
Inline Bin Size:	25.00 m	Min Offset:	50.00 m
Crossline Bin Size:	25.00 m	Max Offset:	707.11 m
Inline Bin Count:	40	Area	
Crossline Bin Cour	it: 40	Min Fold:	0
Total Bins:	1190	Max Fold:	9
Total Traces:	3364	Min-Max Areal:	0.74 sq.km
Illuminated Bins:	841	Res	et

2) Draw the contours of the polygon using the mouse by clicking on <u>Mouse</u> <u>Selection</u>. In the meantime the <u>Survey Statistics</u> dialog is minimized and the left mouse button is used to draw a polygon. Once finished, click the right mouse button, after which the <u>Survey Statistics</u> will reappear and the corresponding <u>Area</u> will be calculated.



The result:

Mouse Selected Poligon:			
Area:	0.32 sq.km		
Mouse Selection			

7.3.5 Selected Bin Informartion

After activating the option <u>Selected Bin Information</u>, click on any bin and this will bring up the <u>Selected Bin Statistics</u> dialogue with contains statistical information for that particular bin. While in this mode you can switch between the bins and the <u>Selected</u> <u>Bin Statistics</u> dialogue will change accordingly.

Selected Bin S	tatistics				×	
Bin		Attributes				
Number:	1120	Fold:	4	Median Offse	et: 291.55	
Centre X:	662.50	Min Offset:	212.13	Offset Rang	e: 141.42	
Centre Y:	312.50	Max Offset:	353.55	Largest Ga	p: 79.42	
		Mean Offset:	287.20	Offset Variabilit	y: 117.21	
Offset Azimuth						
0 707.11 INCRIMENT: 176.78 Show Spider						

The dialogue consists of three parts: the first one <u>Bin</u>: its serial number according to the origin and the coordinates of the seismic survey; second <u>Attributes</u> contains the statistics for that bin; and the third part – the graphic statistics for the offset and azimuth corresponding to the <u>No Color display</u> for both **Offset** and **Azimuth**.

Also there is a button <u>Show Spider</u> - to display all source-receiver pairs whose midpoints fall in a selected bin, in the form of a spider. To turn off the spider display press the <u>Hide Spider</u> button.



To exit this mode you need to deactivate the <u>Selected Bin Information</u>.

7.3.6 Plot Statistics

<u>Plot</u> Statistics - a dialogue that displays the statistics for the calculated Fold Map using the following graphs and diagrams:



- Graph displaying the distribution of the **Number of Bins** with respect to the **Fold**



- Graph displaying the distribution of the **Number of Traces** with respect to the **Offset**.



- Graph displaying the distribution of the **Number of Traces** with respect to the **Azimuth**.



The X-axis, depending on the graph, shows the Fold, Offset, Azimuth, and on the Y-axis the Number of Bins or the Number of Traces.



- Radial diagram which shows the distribution of traces according to Azimuth and Offset.



In this radial diagram - each circle corresponds to a particular offset. The scale of offsets is marked on the axes X and Y. The radial lines represent the azimuth and each cell in the pie chart is colored according to the number of traces that fall in each particular range of offset and azimuth.



- Radial diagram which shows the distribution of the Number of Bins according to Azimuth and Offset.



In this diagram, the X axis represents the Offset and the Y axis – the Redundancy (i.e. each cell is colored according to the number of bins that have the same).



This button opens a dialog for optional display settings, where you can set the Increments for <u>Fold</u>, <u>Offset</u>, <u>Azimuth</u>, as well as change the display from line graphs (<u>As Line</u> <u>Graph</u>) to histograms (<u>As Bar Graph</u>).

Display Options	×			
Increments]			
Fold:	1			
Offset:	50			
Azimuth:	10			
Display				
As Line Graph				
🔘 As Bar Graph				
ОК	Cancel			
7.4 Manipulation with Acquisiyion Geometry

7.4.1 Changing position of Inline/Crossline axes

If, for some reason, the program does not correctly determine the Inline / Crossline coordinate system when loading the observation scheme from the SPS-file, it is possible to change the location of the axes, for example, as in the figure below. To do this, you need to activate the mode $\boxed{-(Shots / Receivers: Moving with rotation})}$, hold down the *ctrl* button and perform manipulation (move, rotate, change the length of one of the axes).

Before

After



7.4.2 Changing coordinates of the Shot/Receiver

To move the Shot/Receiver to the exact coordinates, you need to activate the mode - (<u>Moving Shot and Receiver Lines</u>) and then point to <u>Shot / Receiver</u> and click the left mouse button.



Then in context menu you need to select the <u>Shot/Receiver Coordinates</u>. A dialog will appear with the current coordinates Shot / Receiver <u>Map</u> - coordinates of the map, and <u>SPS</u> - location in the Inline / Crossline observation scheme, **Z** - current depth of the Shot / Receiver.

Selected Shot/Receiver Coordinates						
		Мар	SPS			
	X:	600	600	Z: 0		
	Y:	600	600	Set		
	_					

If you need to get the coordinates of another Shot / Receiver, you can repeat the procedure without closing the dialog. After changing one of the coordinates, you must press <u>Set</u>, then <u>Shot/Receiver</u> position will change its location or depth. After receiving the desired result you have to close the dialog.

7.4.3 Changing the depth of Shots/Receivers

The button - (<u>Set Shots / Receivers Depth</u>) opens a dialog, where you can set the depth for all Shots / Receivers. There are two ways to get the depth value: the first is to set the depth manually, the second one is relative to the selected surface from the list loaded into the project.

Set Shots/Receivers Depth				
	Shots Receivers			
🔘 Static Depth	0 0			
Output from Layer	PRECAMB(1)-local.grd			
	OK Cancel			

After selecting the depth setting method, you need to determine what the depth of Shots or Receivers will be assigned to, or both, and activate the corresponding flags. After selecting the settings, click OK.

7.4.4 Placement of Shots/Receivers in Well



To change the initial placement of receivers in a well or to place sources in a well, use the menu command <u>Map/3D Survey Edit Modes/Moving Shot and Receiver</u> <u>Lines</u>. Then, in the appeared dialog select a well (from the list of database wells which belong to the selected fields and include trajectory specification in the inclinometry table):

Moving Shots / R	Noving Shots / Receivers X				
Selection Type Shots R Cable Poi Change Src/Rec	Selection Type Shots Receivers Cable Point Line Polygon Change Src/Rec (Only VSP)				
Point:	Action:	Type:			
Receiver 🗸	Add \sim	Below 🗸			
From:	To:	Step:			
0	2800	0			
	w	ell: 272 ~			
Select	Apply	Cancel			

Start from selection of a station type in the <u>Point</u> list: either <u>Receiver</u> or <u>Source</u>. Then use the list Action to select an operation: either Add or Remove.

Moving Shots / Receivers X	Moving Shots / Receivers X
Selection Type Shots Receivers Cable Point Line Polygon Change Src/Rec (Only VSP) Point: Receiver Add Interval V Receiver Source Well: 272 V	Selection Type Shots Receivers Cable Point Line Polygon Change Src/Rec (Only VSP) Point: Receiver Add Interval Step: 0 Well: 272 V
Select Apply Cancel	Select Apply Cancel

Then select a desired type of object in the list <u>Type</u>:

Moving Shots / Receivers X	Moving Shots / Receivers X
Selection Type Shots Receivers • Cable ○ Point ○ Line ○ Polygon Change Src/Rec (Only VSP) Point: Action: Trom: To: 0 2800 Well: Z7Z	Selection Type Shots Receivers • Cable ○ Point ○ Line ○ Polygon Change Src/Rec (Only VSP) Point: Action: Receiver ∨ Remove ∨ From: To: 0 2800 Well: 272
Select Apply Cancel	Select Apply Cancel

The action Add supports the next objects:

<u>Interval</u> requires entering the first depth along well in the field <u>From</u>, the last depth of the interval in the field <u>To</u>, and the depth increment from station to the next station in the field <u>Step</u>:

From:	To:	Step:
1000	1500	50

The result:



2) <u>Above</u> requires entering the last depth along well in the field <u>To</u>, and the depth increment from station to the next station in the field <u>Step</u>:



3) <u>Below</u> requires entering the first depth along well in the field <u>From</u>, and the depth increment from station to the next station in the field <u>Step</u>:

From:	To:	Step:
2500	2800	50

The result:

4) <u>Depth</u> along the well is entered in <u>Z</u>:



The action Remove supports the next objects:

1) <u>Interval</u> requires entering the first depth along well in the field <u>From</u>, and the last depth of the interval in the field To:



2) Above requires entering the last depth along well in the field To:

From:	To:	Step;	
0	1500	100	

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The result:



3) <u>Below</u> requires entering the first depth along well in the field <u>From</u>:



4) <u>All</u> means removal of all stations in the survey and does not need additional parameters.

Using the listed operations and objects one can form the combined surveys not covered by the basic set of acquisition geometries (such as VSP with varying step, inter-well sounding, "inverse" VSP with sources in the wells, combinations of surface observations with VSP, etc.).

8 3D Ray-tracing

To perform 3D Ray-tracing in Tesseral Pro it is necessary to have a 3D Velocity Model in SEG-Y format (see 13.4), reflecting surface in one of standard formats (see 14.1) and 3D survey layout (see 7).

You can see explanations on how to create a job and run 3D Ray-tracing in Chapter 8. You can find some specifics of viewing modeling results in Chapter 15.

8.1 3D Ray Tracing Modeling

To simulate 3D Ray tracing in Tesseral Pro, you need to create a 3D model consisting of a 3D velocity Model in Seg-Y format (see 13.4), a reflecting surface in one of the standard grid formats (see 14.1) and create a 3D survey layout (see 7).

8.1.1 Previewing 3D Velocity Model

In order to preview the 3D velocity model as a SEG-Y file, the user can load it into the Seismic Frame (see Section 13) and then display it in 3D View Frame (see Section 15).

To load the 3D SEG-Y file, choose one of the <u>File > Load Seismic File</u> or <u>Seismic > Load Seismic File (New Frame)</u> menu commands. Select the file in the standard File Open dialog box, and in the dialog



choose <u>'Model or Migrated gather'</u>. Your choice is remembered and next time you load the same file, you will not be asked.

The file will open in the new Seismic Frame.



More details on managing and displaying 3D Model files can be found in Section 73.4 You can also display the same 3D Model file in 3D view. To do this, create a new <u>3D</u> <u>View Frame</u> by the <u>3D View > View Data Cube (New Frame)</u> menu command. In the <u>Add Items</u> dialog box, select the file you want to view:



Then the 3D Velocity model is displayed in the 3D View:



See Section 15 for details on 3D View options.

NOTE: It is not necessary for 3D ray tracing procedure to have the 3D velocity file loaded into the interface. But this step is useful for previewing the file and making sure you choose the right file for the simulation.

8.1.2 Loading the Reflecting Surface

The reflecting surface can be in any of the standard grid formats (see 14.1). To load it, choose the <u>File > Load Map File</u> menu command. If a <u>Map Frame</u> is not created, it will be created and the file loaded. Alternatively, you can use the menu <u>Map > Create Map (New Frame)</u> and in the dialog box select <u>"Load TXT or GRD-surface files"</u>.

When loading surface, you will be asked about creating isolines. This is only for display and is optional. After that, you will be presented with the <u>Surface properties</u> dialog:

Surface properties		×
Name PRECAMB(1)-local.grd		2
Value interval Min (depth) 3040.378005044 Max (depth) 3380.944184191		3.
Clipping		2
	$\frac{1}{2}$	L.
OK Cancel		

More details on the options in this dialog and on working with the Map Frame can be found in Section 14. After you click OK, the surface is loaded into the Map Frame



8.1.3 3D Ray Tracing simulation

Before you start the simulation, you need to create the 3D survey layout (see Section 7). Here is an example of a reflection surface and a 3D survey layout.



To start the 3D Ray Tracing simulation, choose the Run > 3D Ray Tracing Modeling... menu command. If you have not saved the project, you will be prompted to do so. After that, the <u>3D Ray Tracing</u> dialog box opens:

O Ray Trac	ing					×
Input Velocity Cubes Compressional IPLEX_VELOCITY_MODEL_newsort_revers.sgy Shear (optional)						
Horizon	File ,3D Ray	Tracing files\CCA	T(2)_local.grd	Grid forma	at Surfer GRD	•
From #	¢: 282	To #:	282	A	Active]
Region C	ube					
X min	35	m X max	3955	m X step	10	m
Y min	35	m Y max	4515	m Y step	10	m
Z min	0	m Z max	4070	m Z step	5	m
Set initia	al values from:	Velocity Cu	be Su	urface (Horizon)]	
Output Illumination File Name OutputIlmn.grd Rays File Name OutputRays.txt						
Wave type PS						
Observe Attenuation due to Ray Divergence						
Computation parameters Output Folder ry Internet Files\Content.Outlook\3MOTZSY0\						
Mode: Precise Fast Threads per process Max						
				RUN	Car	ncel

You can change the following options:

• <u>Output Folder</u> Specifies the folder where the input files and the computation results are stored.

• <u>Velocity Cubes</u> Specifies the 3D velocity SEG-Y file used for the 3D Model (see *8.1.1*). The Shear Wave Velocity cube is specified in case of PS wave ray tracing, otherwise the Vs values are generated automatically according to Castagna's equation (i.e. the mudrock line).

• <u>Horizon File</u>. Specifies the reflection surface file (see 8.1.2)

• <u>Horizon File Type</u>. Specifies the file type used for the reflection surface. See details in 14.1

• <u>Sources to compute</u> group. Specify the range of sources to compute. Input the range into the edit fields or click the button <u>All</u> to compute all sources, or <u>Active</u> to compute only the active selected source in the 3D survey layout (see 7)

© 2019-2021 Tesseral Technologies -*User Documentation*- • <u>Region Cube</u> group. Specify the 3D Model region for computation or use the button <u>From Velocity File</u> or <u>From Surface</u> to set the region based on the corresponding ranges in the files.

Also in this group, specify the computation steps. The <u>X</u> step and <u>Y</u> step determine the spatial density of rays during the computation, while the <u>Z</u> step determines the internally used time step and influences the number of links each ray contains.

NOTE: Do not set unnecessarily small values into the step boxes; doing so will significantly increase the computation time.

• <u>Illumination File Name</u> specifies the name of the surface file where the illumination map will be saved after the computation.

• <u>Rays File Name</u> specifies the name of the file (or group of files) where the rays from the sources reaching the receiver will be saved after the computation. The file name will be automatically amended with the source index, and one file will be created for each source in the 3D survey layout.

• The user can also choose to take into account the <u>Attenuation due to</u> <u>Ray divergence</u> and select between 2 modes of computation <u>Fast</u> and <u>Precise</u>. For the <u>Precise</u> mode Snell's Law of reflection and refraction will be taken into account and the rays will bend according to the elastic properties of <u>Velocity Cube File</u>. In the <u>Fast Mode</u> the incident and the reflected waves will remain perfectly straight.

🔁 3D Ray Tracing	
Progress	Hide
<< 3D Ray Tracing >> 00:00:29	Torminato
- Point 2 of 1	
0%	
- Overall	- 36
25%	
	Clean
Y [3000 6000], step 10 Z [0 5000], step 20 Output Illumination File Name: OutputIlmn.grd Rays File Name: OutputRays.txt Prepare dataStarting computations <<< 3D Ray Tracing >>> started at Sun Sep 15 22:38:05 2013 100% (Overall: 25%) - 1 of 4. 0:00:27 elapsed.	

Click RUN, and the simulation will start. The usual Computation dialog is displayed.

8.1.4 Viewing the Illumination map

After the computation finishes, the resulting illumination file is loaded into the <u>Map</u> Frame. (You are prompted to generate isolines, this is optional).



You can load the illumination map at a later time using the <u>File > Load Map file</u> menu command. The file is located in the folder specified in the <u>3D Ray Tracing</u> dialog (see 8.1.3).

Now you can display the reflection surface filled with the illumination map in the <u>3D</u> <u>View Frame</u>. To do this, choose the menu command <u>3D View > View Data Cube</u> (New Frame). The <u>Add items</u> dialog box appears:

Add items	
Seismic	Surfaces OutputIlmn.grd Top PRECAMB(1)-local.grd Top
Vells	OK

Cancel out of this dialog at this time (do **not** click OK).

The empty <u>3D View</u> Frame is created. Now choose <u>3D View > Add Map > From</u> <u>Project</u>. The <u>Add Surface From Project</u> dialog appears:

Add Surface From Project	
All Layers (without already	Layers to be added in the
OutputIlmn.grd Top PRECAMB(1)-local.grd Top	
<	
ОК	Cancel

In the left list (<u>All Layers</u>) select the reflection surface and click '>'. The Surface name will be moved to the next list, <u>Layers to be added</u>.

Add Surface From Project	-	-			_		×
All Layers (without already		Layers to be added in the		1000	2000	3000	
OutputIlmn.grd Top		PRECAMB(1)-local.grd Top					
	>		1000	 			1000
			2000	 			200
	<		3000				3000
			4000	 			4000
ОК		Cancel		1000	2000	3000	

Click OK. In the Surface Properties dialog

ĺ	Surface Properties	
	Name PRECAMB(1)-local.grd; Top	
	X-step 39.5859 Y-step 45.2424	
	✓ Filling by another surface	
1	© Set own interval 2	Filling By Surface
	Auto fitting by surface values	C From file
	O Set general depth interval	
	Apply to all Palette	From project
	OK	3 OutputIlmn.grd; Top PRECAMB(1)-local.grd; Top OK Cancel

Check the "<u>Filling by another surface</u>" check box, and then click "…". In the <u>Filling by</u> <u>Surface dialog box select</u> "From project" radio button, and then select the illumination map surface from the list below. Click OK in both dialogs and the surfaces are loaded into the <u>3D</u> <u>View</u> Frame.



Please refer to Section 15 for instructions on how to adjust the 3D View display options (rotation, zooming, etc.)

8.1.5 Viewing the rays

Choose the <u>3D View > Add/Remove Rays...</u> menu command. In the <u>Open File</u> dialog select the file with the '.bin' extension, having the name specified in the Ray Tracing dialog (see 8.1.3). By default, this file is named "OutputRays.bin". This file contains the catalog of all calculated rays during the simulation.



On the left, you can choose how you want to select the rays: by sources, receivers, or reflection points.

-Select by-		500	1(000	1500		2000	
C Source			+	:	*		:	:
Receiver			+	ŧ			•	
C Reflection Point	0		+ + +	*		* *	*	*
To select rays push left mouse button and move the cursor	200		*				*	* * * * *
I o deselect rays push right mouse button and move the cursor								*
	2500			*			÷ •	÷ •
								* * * *
	3000							*
	Ĭ	- i i	÷	÷	1 1 1	÷	÷	÷



Then select the rays you want to display in the 3D View. Depending on your choice in the left of the dialog, you can select rays by sources, receivers or reflection points. Drag your mouse with the left button pressed to select the sources, receivers or reflection points; if you want to exclude certain sources, receivers or reflection points from the selection, deselect them with the same procedure but using the right mouse button.

When you click OK, the rays from the selected sources, to the selected receivers, or with the selected reflection points will be shown:



The project data tree allows to hide/restore visualization of the selected rays by the checkbox Rays in the tree folder 3D View.



If you want to change the color palette, choose the <u>3D View</u> \rightarrow <u>3D View</u> Frame Properties... menu command and in the <u>General</u> dialog click the <u>Rays Palette</u> button.

The menu command <u>3D View \rightarrow 3D View Frame Properties</u> is used to specify the ray appearance in the next dialog <u>General</u>.

General	×
Top title	Size Width (mm) 311
Plane Font 3D Font	Height (mm) 179
Projection Rays Projective set by	Palette
Axes step 5 🚔 mm	offset angle of incidence reflection point
ОК	Cancel

Use the list <u>set by</u> of the <u>Rays Palette</u> group to select an attribute to be presented by the ray colors. Each of the attributes <u>luminance</u>, <u>offset</u>, <u>angle of incidence</u> is scaled from min to max value among the selected rays and projected to the palette. (A ray has only one color according to the relative value of the selected attribute.) The attribute <u>reflection point</u> is presented differently: the ray parts from source to reflection and the ray parts from reflection to receiver are presented by two different colors (the extreme colors of the selected palette).

The next dialog <u>Palette</u> (called by the button <u>...</u> in the dialog <u>Rays</u> <u>Palette</u>) is used to change colors and (optionally) to limit the correspondent value interval.

Palette								
Magnitude within	16.1411190	19.6309	1461	🔲 Edit				
Palette type	From light blue	to dark blue		•				
Glow (%)	From brown to From light blue From red to da	dark blue <mark>to dark blue</mark> rk blue						
100	Rainbow Uniform scale ((16 colors)						
	Black-and-whit Monochrome	e scale						
🔲 Edit palette	Default Dipolar Default Incremental User scale							
16.5 17	17.5 1	18 18.5	19	19.5				
		Ж	Ca	incel				

8.2 Source grouping for 3D modelling

The user can also implement source grouping (i.e. simultaneous shooting from multiple sources) for any 3D modelling method. In order to implement it, the user will first need to load a surface (see Section 14) and build a 3D observation system (see Section 7). Afterwards select Run>Run 3D Modelling and follow the instructions in Section 5. After specifying all modelling settings click Finish and Run modelling.

Run Modeling	×								
The most important modeling properties is:									
Modeling Procedure	3D Acoustic								
Source	1 shot points								
Shotgahter Record	[04000], step 2								
Wavelet	20 Hz, Ricker								
Snapshots	No								
Enable GPU	Yes								
and others	< Back to Modeling Wizard								
RU	N MODELING Quit								



Click <u>Terminate</u>, as soon as at least 1% of the job has been completed. Once the job has been terminated, locate the *survey3d.txt* file in recently created job folder and open it in Microsoft Excel. The *survey3d.txt* contains the XYZ coordinates of every source-receiver pair of the designed 3D survey (i.e. the coordinates of every trace) and the user will have to fill the entire <u>Inline</u> and <u>Crossline</u> columns with zeros. Afterwards, an identical <u>Source</u> <u>Number</u> needs to be assigned for the sources that need to be grouped. For example if out of 100 sources in the 3D survey, the user wants to group just 5, then a <u>Source Number</u> of 1 (in actuality it can be any number) needs to be assigned to all traces pertaining to those 5 sources. In other words, every row that carries the <u>SrcX; SrcY; SrcZ</u> coordinates of the respective 5 sources need to be filled with the same number. The remaining 95 sources (that are of no interest to us), have to be assigned a different number (even though we do not care about them), for example 2, so that the whole <u>SrcNum</u> column is filled. The same methodology applies if 3 or more sets of sources, have to be grouped per modelling job.

ELE	S = C ² = ∓ HOME INSERT	PAGE LAYOUT	FORMULAS DATA	REVIEW VIEW			survey	3d.txt - Excel						7 E Stefan F	- 5 X Prisacari - O
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3	834	894	0	834	944	0	0	C)	1					
4	834	894	0	834	994	0	0	C)	1					
5	834	894	0	834	1044	0	0	C)	1					
6	834	894	0	834	1094	0	0	C)	1					
7	834	894	0	834	1144	0	0	C)	1					
8	834	894	0	834	1194	0	0	C)	1					
9	834	894	0	834	1244	0	0	C)	1					
10	834	894	0	834	1294	0	0	C)	1					
11	834	894	0	834	1344	0	0	C)	1					
12	834	894	0	1034	894	0	0	C)	1					
13	834	894	0	1034	944	0	0	C)	1					
14	834	894	0	1034	994	0	0	C)	1					
15	834	894	0	1034	1044	0	0	C)	1					
16	834	894	0	1034	1094	0	0	C)	1					
17	834	894	0	1034	1144	0	0	C)	1					
18	834	894	0	1034	1194	0	0	C)	1					
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Once the <u>SrcNum</u> column has all been filled, save and overwrite the existing *survey3d.txt* file with the updated one (make sure to also save it in TXT format). Afterwards, go back your map frame which contains the previously built 3D survey and click <u>Run>Run 3D</u> <u>Modelling>Yes</u>.



Once the computation is complete, the total number of seismograms produced will equal the total number of shot groupings. For the example above, you will end up with a total of 2 shot gathers, (one for the 5 grouped sources and another one for the remaining 95 grouped sources).

8.3 Double couple sources in 3D modelling

It is now possible to simulate arbitrary oriented double couple sources, expressed by stress matrices (or moment tensors) in *survey3d.txt*.

This functionality can be implemented for any 3D modelling method (except for the 3D acoustic).

In order to implement it, the user will first need to load a surface (see Section 14) and build a 3D observation system (see Section 7). Afterwards click <u>Run>Run 3D Modelling</u> and follow the instruction in Section 5. After specifying all modelling settings click <u>Finish</u> and Run modelling.

Run Modeling	x									
The most important modeling properties is:										
Modeling Procedure	3D Acoustic									
Source	1 shot points									
Shotgahter Record	[04000], step 2									
Wavelet	20 Hz, Ricker									
Snapshots	No									
Enable GPU	Yes									
and others	< Back to Modeling Wizard									
RUN	N MODELING Quit									



Click Terminate, as soon as at least 1% of the job has been completed.

Once the job has been terminated, locate the *survey3d.txt* file from the recently created job folder and open it in Microsoft Excel. The *survey3d.txt* contains the XYZ coordinates of every source-receiver pair of the designed 3D survey (i.e. the coordinates of every trace) and the user will have to fill the entire <u>Inline</u>, <u>Crossline</u> columns with zeros and the <u>SrcNum</u> with -1, which simply disables it during computation!

	5 - c≥ - ÷						survey	3d.txt - Excel						7 0	1 = 8/9
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3	894	1 (0 834	944	0	0	C	-1	0.707	-0.707	0	0	0		0
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6	894	1 (0 834	1094	0	0	C	-1	0.707	-0.707	0	0	0		0
7	894	1 (0 834	1144	0	0	C	-1	0.707	-0.707	0	0	0		0
8	894	1 (0 834	1194	0	0	C	-1	0.707	-0.707	0	0	0		0
9	894	1 (0 834	1244	0	0	C	-1	0.707	-0.707	0	0	0		0
10	894	1 (0 834	1294	0	0	C	-1	0.707	-0.707	0	0	0		0
11	894	1 (0 834	1344	0	0	C	-1	0.707	-0.707	0	0	0		0
12	894	1 (0 1034	894	0	0	C	-1	0.707	-0.707	0	0	0		0
13	894	1 (0 1034	944	0	0	C	-1	0.707	-0.707	0	0	0		0
14	894	1 (0 1034	994	0	0	C	-1	0.707	-0.707	0	0	0		0
15	894	1 (0 1034	1044	0	0	C	-1	0.707	-0.707	0	0	0		0
16	894	4 (0 1034	1094	0	0	C	-1	0.707	-0.707	0	0	0		0
17	894	1 (0 1034	1144	0	0	C	-1	0.707	-0.707	0	0	0		0
18	894	1 (0 1034	1194	0	0	C	-1	0.707	-0.707	0	0	0		0
19	894	1 (0 1034	1244	0	0	C	-1	0.707	-0.707	0	0	0		0
4	survey3d	÷							: 4						

Introduce the moment tensor for <u>KTau11</u>, <u>KTau22</u>, <u>KTau33</u>, <u>KTau12</u>, <u>KTau13</u>, <u>KTau23</u>, for all relevant sources.

Please make sure to assign identical moment tensors to all traces, pertaining to a unique source. In other words, the moment tensor needs to remain constant for every source-receiver pair in the table.

Once the \underline{KTau} columns have been filled, save and overwrite the existing *survey3d.txt* file with the updated one (make sure to also save it in TXT format).

Now open the *runtask.ini* file, located in the same modelling folder as *survey3d.txt* and change

[Source] Type=0; Omnidirectional to [Source] Type=10; Double Couple

Afterwards, save the *runtask.ini* file (File>Save) in the exact same location.

Then, go back your map frame which contains the previously build 3D survey and click Run>Run 3D Modelling>Yes.





8.3.1 Using the same moment tensor for all sources

If the user would like to use the same moment tensor for all sources in the 3D survey, then it is sufficient to **ONLY** modify the *runtask.ini* file as follows (leaving the *survey3d.txt* intact):

Remove [Source] Type=0; Omnidirectional And replace it with: [Source] Type=8; K11=...; K22=...; K33=...; K12=...; K13=...; K23=...;

Once the moment tensor has been specified, save the *runtask.ini*, go back to your map frame which contains the previously build 3D survey and click <u>Run>Run 3D</u> Modelling>Yes.


8.3.2 Using 2D douple couple sources for 3D modeling

It is also possible to have all double couple source propagate in 2D only (i.e. in XZ, YZ or XY direction). For that you will have to modify the *runtask.ini* file as follows:

Remove:

[Source] Type=0; Omnidirectional

And replace it with:

[Source] Type=8; DoubleCoupleAxis=XZ

Or

Type=8 DoubleCoupleAxis=XY

Or

Type=8 DoubleCoupleAxis=YZ

Afterwards, save the *runtask.ini*, go back your map frame which contains the previously build 3D survey and click Run>Run 3D Modelling>Yes.



9 3D Full-Wave Modeling

To run 3D Acoustic and Elastic full-wave modeling you'll need to:

- 1. Build a 3D model as a seismic cube SEG-Y file (.sgy)
- 2. Setup 3D survey geometry
- 3. Setup modeling parameters

9.1 3D model as a seismic cube

Using command $\underline{\tt Map} > \underline{\tt Create} \ \underline{\tt Map}$ create new frame $\underline{\tt Map}$ with the surfaces form DB or GRD-files



Use command Map > Section mode to draw the section (profile) line on Map frame. The section with the layers should appear in top title.



If you can't see the section, please expand the heading area by the mouse.

The highlighted by red color layer is the currently active one (it is shown in the frame). Right-click on top title and select the command <u>«Select Layer</u>» to choose another active layer. Then right-click on button <u>«... 3D model»</u>.



This command can also be accessed by menu $\underline{Map} > Active Map > 3D model properties$.

In the dialog <u>3D model properties</u> option <u>Map type</u>: select <u>top</u> to assign velocity values *beneath* the surface, or bottom – *above* the surface.



Then right-click on section and use command <u>Select Layer "..."</u> and <u>"..."</u> 3D <u>model Properties</u> to specify velocities in all layers.



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For adjusting palette of the section's velocities (not map) use the button «Edit Bottom <u>Title</u>» in the Map > <u>Map Frame Properties</u> dialog, then «<u>Show Section</u> Palette».

Map Bottom Titl	e		×
Size			
Width (mm)	85		Font
Hight (mm)	72		Background
Palette Show 9	Section Palette	eight (%)	
🗸 Axis			
 Section 	Autocalc Depth		
	Top 27.8	m	
	Bottom 5197.6	m	
	Fill		
	Section Palette type		
	c	к	Cancel

To create 3D SGY file use command $\underline{Run} > \underline{Map}$ Frame > Create 3D Seg-Y and adjust grid parameters:

If there is no velocities data in the model, the program will use the default values.

Create 3D Seg-Y	Model					×
Output seg-y file	C:\TE	MP\2014-02-0	7\aaaa.sgy			
	 □	parameters —				
		Min	Max	Step	Size	
	х	1750	6950	50	105	
	Y	2400	6500	50	83	
	Z	0	5150	50	104	
		Set "Mir	n" and "Max" fror	n Map Frame		
	Fillin	g cells				7
	Valu	e by default	6000	K		
		Filling of empty	/ values from the	upper cells		
				OK	Can	cel

Result:



When you have 3D model as seismic SGY file with the cube of velocities, open it:



Seismic Properties	×
Common Plane Trace Scale	
_ Show	Profile Line
View Mode: View as a model	✓ Extend line
Traces per page: 100	by: 20 m
✓ Draw horizontal section ✓ Popup current shot's X,Y	
Coordinate Orientation	Receivers
	C Black crosses
	C ay dots
	Contour
	C None
OK Cancel	Apply Help

It is handful to change seismic view mode to "Contour" in the Seismic Frame's properties

9.2 Design 3D acquisition geometry

Next step is creating of a Map Frame to build 3D acquisition geometry



Use the Acquisition Geometry Wizard to design the survey. These steps are skipped here. For detailed description of 3D survey design please see section 7 of this manual. It is important, however, to specify inline and crossline lengths of the observation zone.

Sun	vey bearings								×
,									
	ORIGIN (0:0):	X beg.	0	m	Y beg.	d		m	
	INLINE:	Lenght	1000	m	Azimuth	0		deg	
	CROSSLINE:	Lenght	1000	m	Azimuth	+90	•	deg	
									1
		<	Back 🛌	Finish		Cancel		Help	
							_		

After the acquisition geometry is built now let's place the 3D seismic cube into the map and combine it together. Click on "Edit Frame Properties" button as shown below:



Enable "Draw Seismic frames plan" to combine the model with acquisition geometry on the map:

Map Properties	—
Edit top title Size Edit bottom title Width 104 m Height 66 m	m Font Palette Background
Project Properties and Coordinate orientation Work area	Ruler
Active Layer Image: Show Grid (fill color) Image: Draw Isoline Font height (%)	Isolines Properties
Database wells Well Title At collar Name Value Color Font height (%) Boothtrace Draw Well Inclinometry	Acquisition Geometry Image: Construction of the second
Seismic plan view Draw Seismic frames plan Draw sources from seismic file Load	OK Cancel

Click on "Zoom Out" several times so the seismic cube's area became visible on the map. Switch to "Move and Rotate" mode and drag the acquisition geometry into the model area.



Now, click on "Unzoom" and "Arrange Frames" to see the model with the acquisition survey.



You can continue to design the survey by moving and rotating inline and crossline positions on the map. 2D profile drawn on the surface of the model seismic cube will be visible also on the map.



9.3 Setup modeling procedure and boundaries

After the seismic cube velocity model is loaded and the survey had been set up use either <u>"Run > Run 3D Modeling ...</u>" to setup and run the full-wave modeling or "<u>Run ></u> <u>CLUSTER: 3D Modeling ...</u>" to create modeling job for Linux cluster.



To run acoustic or elastic simulation a P-velocity cube must be provided. Density can be calculated automatically based on built-in correlation tables. The elastic simulation of the S-velocity cube may also be provided or calculated automatically.

Simulation of the special boundaries is automatically configured using P-velocity cube. These boundaries could be adjusted manually if needed.

[3D Modeling General Properties
	Method Modeling Procedure: 3D Acoustic Velocity
	Input Cube P-Velocity Cube File D:\Workdir\Test\Model3D.sgy S-Velocity Cube File Browse Browse Not Used
Select Sho Points to simulate	Density Cube File Browse Auto Sources to compake From #: 100 To #: 100 All Active
	Shotgahter Record Model Boundaries Model Boundaries Model boundary will be determined by the velocity cube, but also it can be specified manually (to decrease depth for example)
Yo in v sav	Save results to D:\Workdir\Test\Task\ Du can specify a folder which the task will be ved. Back Next > Finish Cancel Help
Select Sho Points to simulate Yo in v sav	S-Velocity Cube File Density Cube File Sources to compose From #: 100 To #: 100 All Active Model Boundaries Model Boundaries Model boundary will be determined by the velocity cube, but also it can be specified manually (to decrease depth for example) Save results to D:\Workdir\Test\Task\ Browse Browse D:\Workdir\Test\Task\ Browse D:\Workdir\Test\Task\ Browse D:\Workdir\Test\Task\ Browse D:\Workdir\Test\Task\ Browse D:\Workdir\Test\Task\ Browse D:\Workdir\Test\Task\ Browse D:\Workdir\Test\Task\ Browse D:\Workdir\Test\Task\ Browse D:\Workdir\Test\Task\ Browse D:\Workdir\Test\Task\ Browse Browse

Specify signal form, frequency and direction



3D Acoustic Calcula how it aff	equency could be changed to see
Computation Grid Properties Signal Frequency 2 Cell (dx, dy, dz) 12 Tact (dt) 1 Generate 2D snapshots Start 0 ms Step 50 ms Generate by every 1 = Margin 500 m	Hz Threads per process Max m auto Image: Threads per process Max Image: Threads per process Max Image: Threads per process Max Image: Threads per process Max Image: Threads per process Max Image: Threads per process Max Image: Threads per process Max Image: Threads per process Max Image: Threads per process Max Image: Threads per process Max Image: Threads per process Max Image: Threads per process Required Memory (Host): 634 MB ? Required Memory (GPU): 1.5 GB ? ? Image: Generate Time Field X Step: 12 m m Image: Y Step: 12 m m auto 2 Step: 12 m Image: The process PML for invisible boundaries Max Max Max Max Image: Thread to the process of the process Max Max Max Max Max Image: Thread to the process PML for invisible boundaries Max Max Max Max Max Image: Thread to the process
You can use 'auto' buttons to set the special and temporal simulation steps	Margin also affects required memory Margin also affects required to run the simulation
	< <u>B</u> ack <u>N</u> ext > Finish Cancel Help

9.3.1 Run 3D simulation on Windows PC

3D Modeling in progress.

After the calculation is completed gathers of the X,Y,Z particle velocity and the pressure will be generated.



9.3.2 Run 3D simulation on Linux Cluster

The task contains:

- 1. The model seismic velocity cube
- 2. Acquisition geometry (survey32.txt)
- 3. Task settings (runtask.ini)

You can put this folder to a Linux cluster to run the faster parallel computation. Also the cluster engine will use all available memory to handle very large computation jobs.

Solution → Test → Task	✓ 4→ Search Task	
Organize 👻 Include in library 👻 Share w	ith ▼ Burn »	:= - 1 🔞
Videos 3D Model Cube Model3D.sgy runtask.ini Survey32.txt Local Disk (C:)	Date modified 23.11.2007 12:40 03.12.2013 16:47 03.12.2013 16:47	Type SGY File Configuration sett Text Document
Modeling task settings 3 items State: 3 Shared	Acquisition geometry	

10 Processing of seismic gather

Some of the commands in the Run menu are for processing generated synthetic gathers.

IMPORTANT NOTE!

All processing history and user defined settings are saved in the $\verb+computation.log+$

10.1 General Purpose Procedures

The command <u>export Model to Seismic Format</u> is to save the <u>Model</u> Frame into a 2D grid of seismic format.

In the <u>Model</u> Frame, the model consists of polygons (model in vector format). In some other programs such as ray tracing, migration and other processing procedures in Tesseral Pro, the input model is assumed to be in form of grid. To export <u>Model</u> Frame to a grid file, use the command <u>Model > Export to Seismic Format (SEG-Y, TGR)</u>.

	Seismogram calculation	
	Seismic file name	Create a standard name for the output file
Grid step in the output file	C:\Users\Stefan\Desktop\Tesseral Data\Tests\SGY\Vertical_Inc Sampling Rate Step by lenght 47 m Step by depth 50 m	
Create files with grids of anisotropy	Export Medium Anisotropic Properties	
Limitations for values of parameters (in case thin-layering is formed from logging curves)	Components: value range Cancel	
	4	
\backslash	Components: value range	
	Component Units Min value Max value	
	Compressional velocity m/s 100 10000	
(Density kg/m^3 1000 3800	
	Shear velocity m/s 0 6000	
	OK Cancel	

The output file may be in SEG-Y format. For isotropic model, 3 output files are created for the compressional velocity, shear velocity (<name of the output file>–PQR_R.SGY) and density (<name of the output file>–PQR_Q.SGY) components respectively.

The output grid files may be in TGR format (i.e. the internal Tesseral format). Separate output files are created for all 3 components of the depth model (compressional, shear velocity and density), as well as anisotropy parameters if the checkbox <u>Export Medium</u> Anisotropic Properties was checked.

10.1.1 Copy Gather to SEG-Y Format

 $\frac{\text{The command } \text{Run} > \text{General Purpose Procedures} > \text{Copy Seismogram}}{\text{to SEG-Y Format}} is used to transform files from the internal TGR or SDC PC formats into the standard SEG-Y format.}$

Copy seismog	gram to seg-y format		
Input file	C:\Sheldon\TestingOfTesseralPro\Run\Md2+SnapEP.tgr		
	Component Vertical Particle Velocity		
	☐ Write coordinate from model		
Output file	C:\Sheldon\TestingOfTesseralPro\Run\Md2+SnapEP-VIEW.sc		
	OK Cancel		

The TGR format does not contain the geographical coordinates of the traces and the altitudes of the receivers. Check the box <u>Write coordinate from model</u> to obtain this information from the <u>Model</u> Frame and then write it into the trace header of the output SEG-Y file.

10.1.2 Split Seismogram by Shotgathers

The command <u>Run > General Purpose Procedures > Split</u> <u>Seismogram by Shotgathers</u> is for splitting merged synthetic gathers into separate files in terms of the number of shot points (one file for each shot gather).

Split seismo	gram by sources
Input file	C:\Users\Stefan\Desktop\Tesseral Data\M1+GathAP-Z.sgy
	OK Cancel

10.1.3 Split SEG-Y File into Pieces of Limited Size

The command <u>Run > General Purpose Procedures > Split SEG-Y</u> <u>File by Limited Size Pieces</u> is to split the SEG-Y files into separate files, each file not exceeding the size specified in the <u>Output file Size (MB)</u> parameter.

Split SEGY File		×
Input file	C:\Sheldon\TestingOfTesseralPro\Rur	n\Md2+GathEP.sgy
	Output File Size (MB)	1000
	Temporary Memory Buffer Size (MB)	100
	0	K Cancel

10.1.4 Merge Seismograms

The command $\underline{\text{Run}} > \underline{\text{General Purpose Procedures}} > \underline{\text{Merge}}$ <u>Seismograms</u> is for merging the selected files into one (the output file will have all the traces of the input files in the same order as they were entered in the list). If the coordinates of the selected files match each other exactly, the procedure will work differently (it will stack the traces and the output file will have the same number of traces as the input one). This procedure can be used to sum the different cubes after migration.

ſ	Merge seismogra	ams	X]
	Files to merge	C:\Sheldon\TestingOfTesseralPro\Run\Md2+GathEP-1.sgy C:\Sheldon\TestingOfTesseralPro\Run\Md2+GathEP-2.sgy		Add file(s) to the group
		C:\Sheldon\TestingOfTesseralPro\Run\Md2+GathEP-3.sgy	X	
				Delete file(s) from the group
	Component	V		
		Delete original files after successfull merging		
	Output file	C:\Sheldon\TestingOfTesseralPro\Md2+GathEP.sgy		
		Cance		

10.1.5 Cut Out Cube/Section

The command $\underline{\operatorname{Run}}$ > General Purpose Procedures > Cut Out $\underline{\operatorname{Cube}/\operatorname{Section}}$ is mainly used for preparing field gathers for duplex wave migration or for extracting part of the traces falling into a user-defined rectangle. It can speed up DWM processing for a huge dataset.

ĺ	Cut part of cub	De	x
	Input file	C: \Sheldon \TestingOfTesseralPro \Run \FieldG	athers.sgy
Only traces inside the rectangle will be in a output file.	the	X from m	
		Y from m	
		Y to m	The condition for selecting traces
	Add trace if	Source or Receiver	legion
	Output file	C:\Sheldon\TestingOfTesseralPro\FieldGathe	rs-CUT.sgy
		OK	Cancel

10.1.6 3D Replication

The command $\underline{\texttt{Run}}$ > General Purpose Procedures > 3D Replication is used for:

• Creating the 3D acquisition data (multiple shot lines) from a single shot line (with multiple receiver lines) generated by 2.5D modeling to create a true 3D dataset from 2D acquisition.

- Creating a 3D velocity model from a 2D velocity model.
- •

•	C-:) liti		X	D
	Seismogram 3D replication Input file C:\Sheldon\TestingOfTesseralPro\Run\Untitled-PQR.TGR				
		Component	Compression Velocity	•	
Initial coordinates and azimuth of the profile	Inline (Profile	.)	Crossline		The lines in the output 3D file
	Azimuth	0 m	Left Limit 0	m	
	X beg.	0 m	Right Limit 0	m	
	Y beg.	0 m	Step 0	m	
	Output file				

NOTE: <u>Input</u> File is a depth velocity model or gathers of a single shot line (grid in SEG-Y or TGR format). To obtain depth velocity model in SEG-Y or TGR format, the command Model > Export to Seismic Format (SEG-Y, TGR) is used.



10.1.7 SEG-Y File Resampling

Choose the command <u>Run > General Purpose Procedures > SEG-Y File</u> Resampling.

Resampling	×
Input file	C:\Sheldon\TestingOfTesseralPro\Md2+GathEP.sgy
Output File	tingOfTesseralPro\Md2+GathEP-RESAMPLING.sgy
	Input file trace step 2
	Output file trace step 4
	Cancel

10.1.8 Difference of 2 Seismograms

The command <u>Run > General Purpose Procedures > Difference of 2</u> <u>Seismograms</u> is used to calculate the difference between 2 synthetic gathers created by similar models. It may be used, for example, to evaluate how the perturbations of the model's parameters influences the output gather. It can also be used to obtain the differences between migrated cubes or sections.



10.1.9 Import/Export Traces Coordinates

The coordinates of sources and receivers in the headers of the traces can be exported into a text file using <u>Run > Seismic Frame > Export Traces Coordinates</u>.

The coordinates of sources and receivers in the text file can be imported by using <u>Run ></u> Seismic Frame > Import Traces Coordinates.

10.1.10 Write Visible Coordinates to Trace Headers

To write the modified coordinates of traces to the headers of seismic files, the command Run > Seismic Frame > Write Visible Coordinates to Trace Headers is used.

In Tesseral Pro, the seismic files can be displayed with transformed/rotated coordinates using the following commands:

• <u>Seismic > Rotate to Align X Axis along Section Profile</u>

• <u>Run > General Purpose Procedures > Import Traces</u> Coordinates (load coordinates of traces from text files)

 $\bullet \qquad \underline{\texttt{View} > \texttt{Raw} \texttt{Trace} \texttt{View} \texttt{Window}} \text{ (in this dialogue box, the trace coordinates can be assigned from non-conventional cells of the trace headers).}$

Please see Section 13 for more details.

After using the ways mentioned above to change the trace coordinates, the headers of the seismic files are not changed and the information on trace coordinates is written into an additional file <gather name>.inf for further use in the Tesseral Pro.
10.1.11 Cut Profile from 3D seismogram

This function is used for the extraction of shot gather traces along a straight line or a polyline from a 3D seismogram.

To access this function please load the 3D seismograms (File>Load Seismic file), followed by <u>Run>General Purpose Procedures>Cut Profile from 3D</u> seismogram.

Test.tpa	- Tessi	aniho al	• ×
<u>File</u> Data	base	Edit View Model Map Satamic 30 View Ban Help	
	e	■ ¹	
× ×		$[\exists \fbox \ref{algebra}] \times \# \fbox [\exists \ref{algebra}] \to [b] \land [b$	
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	-		
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		LUGR#X1502.2/million	
	16		1600
			1
		x (end) (1) (1) (1) (1) (1) (1) (1) (1) (1) (1	1800
	-	ten 0 10 10 20 30 40 50 50 70 80 50 100 110 120 130 140 10 10 110 120 130 140 440 450 460 470 480 480	
	F.		
			1
	10		1000
	F.		
	F.		
	20	000	2000
	E		
	1 30	-	3000
	F.		
	Ŀ.		
		1	t. 1.
< > -	(+
Synthetic seis	mogra	ems creating: STIP 1: Create Velocity Model > STIP 2: Acquisition Geometry > STIP 3: Ann modelma > Hole	
For Help, pre	ess F1		

0	Cut profile from	m cube		_			x			
	Input file C:\Users\Stefan\Desktop\3D modeling\Job3D-01\DUPLEX_VEI									
	Profile by line									
		X from	1301	m	X to	1796	m			
l		Y from	1790	m	Y to	1808	m			
		Step	83	m						
		Export o	oordinates A	sis		•				
	Profile from	n seismic f	file coordinates							
		C:\User	s\Stefan\Desktop	\Tesserra	al Pro testir	ng new version\S				
	Survey from SPS file 2.5D result file									
	Output file C:\Users\Stefan\Desktop\3D modeling\Job3D-01\DUPLEX_VEI									
OK Cancel										
_										



If you would like to extract the coordinates by line, then either specify the \underline{X} from, \underline{X} to, \underline{Y} from, \underline{Y} to and Step or draw the profile in the seismic frame Seismic>Edit Mode>Draw Profile before accessing the Cut Profile from 3D seismogram function (for additional information on profiles please see 13.5).

The traces can be also extracted according to the target survey geometry-<u>Survey</u> <u>from SPS file</u> (see Section 3.1.6), or from a text file of traces coordinates - <u>Profile</u> from Seismic File coordinates(see section 10.1.9).

10.1.12 Export Profile to 2D Seismic File

To export a 2D profile from seismic cube, first of all load the 3D cube (<u>File>Load Seismic file</u>), draw the profile in the seismic frame (see 13.5) followed Run > Seismic Frame > Export Map to 2D Seismic file.



Create seismogram from profile								
File Name	C:\Users\Stefa	n\Desktop\3D modeling\DUPLE	X_VELOCIT	Y_MODE	L_newsort_rev			
Traces coord	dinate	Grid propertis						
Real co	ordinate	X axes: Step by length	35	m	ОК			
Along profile		Z axis: Step by depth (5 m		m	Canad			
					Laricel			



10.1.13 Band-pass filter

Band-Pas	s Filter			21			x				
Input fil	Input file nd it's syntetic seismogram\Elastic A2b Model+GathAP-Z.sgy										
Trape	zoid Angles	5				1					
f1	5	Hz	f2	15	Hz	F1F2 F3 F4					
f3	25	Hz	f4	30	Hz	Length 20	ms				
Output file ample model and it's syntetic seismogram\Bandpass filter.sgy											
	0	К				Cancel					

The user can also multiply any signal spectrum in the frequency domain (equivalent to convolution in time domain) with a filter spectrum, by specifying the <u>F1</u>, <u>F2</u>, <u>F3</u>, <u>F4</u> corner frequencies of the trapezoidal frequency band-pass filter, as well as the <u>Length</u> of the filter in time domain.

10.2 Velocity model

These procedures process the velocity model.

10.2.1 Average Velocities from Model

This is done by the command <u>Run > Velocity Model > Average</u> Velocities from Model

Average Velocity Model
Layered Velocity Model in Depth Scale
Input file C:\Sheldon\TestingOfTesseralPro\Run\Untitled-PQR.sgy
Average Velocity Model in Time Scale
Max t0 (msec) 2000 Time Step (msec) 4
Output file C:\Sheldon\TestingOfTesseralPro\Run\Untitled-PQR-VELMOD.sgy
OK Cancel

The <u>Input file</u> is the layered velocity model, which may be obtained from the <u>Model</u> Frame by the command Model > Export to Seismic Format (SEG-Y, TGR).



10.2.2 Depth-to-Time/Time-to-Depth conversion

The command <u>Run</u> > Velocity Model > Depth to time <u>transformation</u> transforms migrated sections (cubes) from depth domain to time domain.

Depth to Time transform	ation	×
Input file (Depth scale)	C:\Sheldon\TestingOfTesseralPro\Run\Unti	tled-PQR.s
	Component	v
Velocity seismic file	C:\Sheldon\TestingOfTesseralPro\Run\Unti	tled-PQR.s
	C Time scale	
	Depth scale Veloc	rity Model
Output file (Time scale)	C:\Sheldon\TestingOfTesseralPro\Run\Unti	tled-PQR-2
	Trace parameters (Output file)	
	From 0 ms	
	To 2000 ms	
	Step 2 ms	
	ОК	Cancel

NOTE: <u>Velocity seismic file</u> is the layered velocity model, which may have been obtained from the <u>Model Frame</u> by the command <u>Model > Export to Seismic</u> Format (SEG-Y, TGR) (please see Section 12.3.1 for details).

NOTE: <u>Velocity seismic file</u> is the file of layered model grid in time domain. It may have been created from the depth model by using the transformation <u>Depth to Time</u> <u>Transformation</u>. It means that, in the procedure <u>Depth to Time Transformation</u>, if the <u>Input file</u> and <u>Velocity seismic file</u> represent the velocity model, the <u>Output file</u> will be the same model but in time domain.

10.2.3 3D Interpolation

With the help of <u>Run>Velocity Model> Interpolation</u>, the user can resample the grid step for any 3D SGY cube by interpolating between adjacent grids.

To implement this function, first of all you will need to load the 3D SGY: File>Load Seismic File followed by Run>Velocity Model>Interpolation.

C:\Users\Stefan	\Desktop\Sta	andard training	material\2D 🔒			
Output cube						
Turn OFF	х	Y				
Min :	35	35				
Max:	3955	4515				
Turn ON						
Point (0;0) :	35	35				
Point (x;0) :	35	4515				
Point (0;y) :	3955	35				
For all :						
Step :	35	35				
	Min	Max	Step			
Ζ:	0	4070	5			
Output model file:						
C: \Users \Stefan \Desktop \Standard training material \2D						

 $\label{eq:Reassignanewgrid} \begin{array}{c} \text{Reassign a new grid} & \underline{\texttt{Step}} & along X, Y, Z, as well as their \underline{\texttt{Min}} \ and \underline{\texttt{Max}} \ in \underline{\texttt{Turn}} & \texttt{OFF} \\ \text{and click} & \underline{\texttt{OK}}. \end{array}$

By default the X, Y, Z coordinates for the whole cube are elected. The $\underline{\text{Output model}}$ <u>file</u> will have the new reassigned grid step, as you can see in its trace headers.

10.3Pre-Processing

These procedures are for preliminary processing.

10.3.1 Gathering

The procedure is intended for extracting gathers by the criteria of common shot point, common midpoint or common receiver point or obtaining gathers with common offsets. The procedure applies for both 2D and 3D gathers. Use the command $\underline{Run} > \underline{Pre-Processing} > \underline{Gathering}$ (GATHER).

Gathering (G	Gathering (GATHER)									
Input file	Input file C:\Sheldon\TestingOfTesseralPro\Run\Md2+GathEP.sgy									
	Compo	nent								
Axis X —		~ ~								
Start	0 m	Bin 1 m								
Stop	5000 m	Mode								
	1	Common Mid Point								
Axis Y —		C Common Receiver Point								
Start	0 m	C Common Shot Point								
Stop	0 m	C Common Offset								
	,	Number of channels								
C Sampli	ng Rate	120								
X Step	25 m	Number of seismograms								
Y Step	0 m	1 *								
Output file	Output file C:\Sheldon\TestingOfTesseralPro\Run\Md2+GathEP-GATHER									
		Cancel								

10.4 Stack (Time domain)

The procedure is for time-domain stacking.

10.4.1 Kinematic corrections (Normal Moveout)

The <u>Normal Moveout</u> procedure applies kinematic corrections to gathers of various type, e.g., common midpoint gathers, common receiver gathers (Gathering program) and common shot gathers. The result is the time domain gathers after NMO correction. Use the command <u>Run > Stack</u> (Time domain) > Normal Moveout (NMO).

Normal Move	out (NMO)	3						
Input file	C:\Sheldon\TestingOfTesseralPro\Run\Md2+GathEP.sgy							
Velocity file	C:\Sheldon\TestingOfTesseralPro\Run\Md2-PQR-VELMOD.sgy							
	⊙ m/s ⊂ ft/s							
	Component	-						
Axis X	Axis Y							
Start	0 m Start 0 m							
Stop	5000 m Stop 0 m							
Output file	C:\Sheldon\TestingOfTesseralPro\Run\Md2+GathEP-NMO.sgy							
	Cancel							

The average velocity model (parameter <u>Velocity file</u>) may be created from layered depth velocity model by the command <u>Run > Velocity Model > Average</u> <u>Velocities from Model</u>. To obtain a time slice of the subsurface image after Normal Moveout correction, use the Stacking procedure.

10.4.2 Stacking

The procedure <u>Stacking</u> is meant for stacking traces with a common coordinate after the <u>Normal Moveout</u>.

Before applying the <u>Staking</u> procedure, the kinematic correction needs to be applied using the <u>Normal Moveout</u> procedure. The command <u>Run > Stack (Time domain)</u> > Stacking (STACK) is used.

Stacking (ST	ACK)
Input file	C:\Sheldon\TestingOfTesseralPro\Run\Md2+GathEP-NMO.sgy
	Component
Axis X —	Axis Y
Start	0 m Start 0 m
Stop	5000 m Stop 0 m
Accuracy	1 m Normalization
	C Average of summed traces
	C Geometric mean of the above
Output file	C:\Sheldon\TestingOfTesseralPro\Run\Md2+GathEP-NMO-STACK.sg
	OK Cancel

Accuracy is the bin size used for stacking common depth point traces.

10.4.3 CMP Stack

This is used for direct creation of time section by common midpoints (midpoint stacks) without applying the procedures <u>Normal Moveout</u> and <u>Stacking</u>. The <u>CMP Stack</u> procedure uses the medium's average velocity (parameter <u>Velocity file</u>). The command <u>Run > Stack (Time domain) > CMP Stack (SUM)</u> is used.

CMP Stack (S	UM)	×						
Input file	C:\\$heldon\TestingOfTesseralPro\Run\Md2+GathEP.sgy							
Velocity file	C:\Sheldon\TestingOfTesser	C:\Sheldon\TestingOfTesseralPro\Run\Md2-PQR-VELMOD.sgy						
	⊙ m/s ⊂ ft/s							
	Component	v						
Axis X —		Axis Y						
Start	0 m	Start 0 m						
Stop	5000 m	Stop 0 m						
Accuracy	1 m	Gradient 0.5						
Output file	C:\Sheldon\TestingOfTesser	alPro\Run\Md2+GathEP-SUM.sgy						
		OK						

The average velocity model may be created from layered depth velocity model by the command <u>Run > Velocity Model > Average Velocities from Model</u>. The <u>Gradient</u> parameter is for NMO stretch mute.

10.4.4 Dip Moveout Stack

The user can also implement a <u>Dip Moveout Stack</u> (which implements NMO correction first, followed by DMO correction and stacking, i.e. 3 in 1).

It is well known that conventional normal moveout correction (NMO) introduces mispositioning of data, and hence mis-stacking when a dip is present. <u>Dip Moveout</u> correction (DMO) is a technique that converts non-zero-offset seismic data after NMO to true zero-offset locations and reflection times, irrespective of dip. The combination of NMO and DMO followed by post-stack time migration is equivalent to, but can be implemented much more efficiently than full time migration before stack (JAKUBOWICZ, H. (1990), A SIMPLE EFFICIENT METHOD OF DIP-MOVEOUT CORRECTION¹. Geophysical Prospecting, 38: 221–245. doi:10.1111/j.1365-2478.1990.tb01843.x)

The <u>DMO</u> Stack procedure uses the medium's average velocity (parameter <u>Velocity</u> <u>file</u>). <u>Step</u> describes the sampling (i.e. binning) for stacking across \underline{X} and \underline{Y} -axes (in case of 3D seismic).

Dip Moveout	Stack (DMO)				×			
Input file	n\Desktop\Tesseral tests\Test\Job-02\Untitled+GathAP-Z.sgy							
Velocity file	esktop\Tesseral tests\Test\Job-02\Untitled-PQR-VELMOD.sgy							
	⊚m/s ⊚ft	:/s						
	C	omponent			-			
Axis X		_	Axis Y					
Start	45	m	Start	0	m			
Stop	950	m	Stop	0] m			
Step	5	m	Step	0] m			
		m		Gradient 0.5				
				0				
Output file	top\Tesseral tests\Test\Job-02\Untitled+GathAP-Z-DMO-2.sg}							
			0	к	ancel			

10.52D/3D Migration

Procedures for the migration of time-domain 2D gathers

10.5.1 Time Pre-Stack Kirchhoff Migration

The procedure is for creating migration image directly from gathers without creating CMP time section or post-stack migration. The command <u>Run > 2D Migration (Time</u> domain) > Time Pre-Stack Kirchhoff Migration (PSM) is used.

Pre-Stack Kirc	hhoff Migration (PSM)		X
Input file	C:\Sheldon\TestingOfTess	eralPro\Run\Md2+GathAP.sgy	
Velocity file			
	⊙m/s ⊂ft/s	Component	v
Profile coor	dinates	Output section	
From (24	00; 0)	Start 0 m	Gradient 0.5
To (53	;75; 0)	Stop 2975 m	
	Adjust	Step 25 m	
Apertures - X-coordina	te (m) Add Delete Delete All	I (m) Ar (m) Add Add Delete	Normalization Just sum Average Average of order 1/2 Average of order 1/4
Output file	Load	eralPro\Run\Md2+GathAP-PSM.sg	у
		OK	Cancel

This migration needs the time-domain average velocity model as input, which may be obtained by using the commands $\underline{Model} > \underline{Export}$ to $\underline{Seismic}$ Format ($\underline{SEG-Y}$, \underline{TGR}) and then $\underline{Run} > \underline{Velocity}$ Model > Average Velocities from Model. Users can specify velocity measurement units in the model ($\underline{m/s}$ or $\underline{ft/s}$).

If the migration aperture is not specified, the program may use the default values. To specify the apertures explicitly, the buttons in the <u>Apertures</u> group are used: <u>Add</u>, <u>Delete</u>, Delete All, Load (from a file), and Save (to a file).

The migrated section is specified by the parameter <u>Profile Coordinates</u> (whose direction is specified by the <u>Adjust</u> button) and <u>Output Section</u> (size and step along the profile). These are mandatory parameters to be input by the user.

The signal stretching is limited by <u>Gradient</u>, whose default value is 0.5. If the gradient is too small, the images will be too "spread"; if the gradient is too big, some objects may disappear.

The result may be normalized (in this case, the noise and the low signals will be amplified). Usually normalization is not applied (the <u>Just</u> sum option).

The migrated time section is saved to the <u>Output file</u>. To transform it from time scale to the depth domain, use the command <u>Run > Velocity Model > Time to</u> <u>Depth Transformation</u>.

10.5.2 Depth Pre-Stack Kirchhoff Migration

The command <u>Run > 2D Migration (Depth domain) > Depth Pre-</u> <u>Stack Kirchhoff Migration (DPSKM)</u> performs the <u>Depth Pre-Stack</u> <u>Kirchhoff Migration</u>. The result is in depth domain. To transform it to time domain, use the command <u>Run > Velocity Model > Depth to time Transformation</u>.

Depth Pre-Sta	ick Kirchho	ff Mig	ration				1.1					×
Input file	Sample mo	del and	l it's synte	tic seismogram	\Elastic	A2b Model+	+GathAP-Z.sg		Gradien	t 0.5		
	⊚ m/s	⊚ ft	/s	Componer	nt 🗌			•	1 1 1 1 1	<u> </u>	1 1 1 1 1	
Model file	lures\Sam	ple moo	lel and it's	syntetic seism	ogram∖£	Elastic A2b N	Nodel-PQR.sg		Min time s from direc	hift t wave 0.1	s	
									Vp/Vs	2		
Profile coor	dinates								Coordinate	es along Z-ax	is	
Start X	1036	m	Start Y	0	m				Start Z	0	m	
Stop X	5836	m	Stop Y	0	m				Stop Z	574	m	
🔽 Use as	output sect	ion		Adjust		Step	2.5	m	Step Z	2	m	
Time estima	ation setting	s	Ar	pertures								
Step	2	m		X-coordinate (2400	(m) Add		T (s) A	(m) A	r (m)			
Margin	50	m		(Delete		0 0.493	0 150	0 150			
					Delete /	*	0	0	0			
							Load		Save			
								Offse	et Restrictions	;		
Output file	C: \Users\	Stefan\	Desktop\S	tandard trainin	ng mater	rial (Processi	ng pro 📖	min(Xs-	-Xr) 0] m max(X	s-Xr) 0	m
Sum in tim	e domain			se GPU		(ОК		Cancel			

For migration, the layered velocity model has to be in depth domain, which may be obtained by using the menu command $\underline{Model} > \underline{Export}$ to $\underline{Seismic}$ Format ($\underline{SEG-}$ Y, \underline{TGR}). The velocity measurement units in the model can be specified (m/s or ft/s).

If the migration aperture is not specified, the program uses the default values. To specify the apertures explicitly, the buttons in the <u>Apertures</u> group are used: <u>Add</u>, <u>Delete</u>, <u>Delete</u> <u>All</u>, <u>Load</u> (from a file), and <u>Save</u> (to a file), each of which invoke a simple dialogue box.

The migrated section is based on the 2D data. The size of the processing area and the corresponding step along the profile (in X direction) is assigned in <u>Coordinates along X-axis</u>.

The signal stretching is limited by the <u>Gradient</u>, whose default value is 0.5. If the gradient is too small, the images will be too "spread"; if the gradient is too big, some intervals may disappear.

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This program uses the eikonal solver to compute time fields. Discretization of the computation grid is specified by <u>STEP X/Z</u> in the <u>Time estimation settings</u> group. The additional frame (<u>Margin</u>) gives the option of removing the influence of the edge effects. It is recommended to set it to 5 - 10 grid steps.

Min time shift from direct wave is used for supressing shot gathers by a particular time interval after the direct wave arrival (if necessary!), in order eliminate unecessary migration noise.

Also, by specifying $\underline{Vp/Vs}$ of the medium directly below the observation system, the user esentially mutes the direct compressional and shear wave on the shotgaters, and therefore eliminates unnecessary migration noise associated with these waves.

10.5.3 2D Duplex Wave Migration

Duplex Wave Migration (DWM) is a newly developed technology capable of imaging events with dips 60 $^{\circ}$ to 90 $^{\circ}$. Duplex waves are strong enough to be used for geological purposes.

Duplex waves get reflected twice: from a sub-horizontal surface followed by reflection from the sub-vertical surface or vice versa. 2D DWM supports only PPP type reflections.



Before running 2D DWM, the user first of all needs to import the 2D synthetic seismograms in SGY format, as well as the 2D model which generated these seismograms. This is done by clicking on File>Open in the upper menu.

Once the model and its respective seismograms have been loaded the user can then proceed to the DWM settings tab by clicking <u>Run>2D Migration (Depth</u> domain)>Duplex Wave Migration.

Duplex Waves	s Migration	_		-						-		X
Input file	Job-02\Pr	ocessing Edited m	odel (ModelBC_Bas	e_CS - Edited +G	athEP-Z.sgy		Reflecting bou	ındary (pol	ygon)			
	⊚ m/s	⊚ ft/s	Component			•	Mbrly			•	Тор	•
Model P file	C:\Users\S	Stefan \Desktop \Le	ismer model∖Mode	ling-Alex\Job-02\	Processing Ec							
Orientation	of Profile in	Plan										
Start X	2000	m Start Y	0 m									
Stop X	4800	m Stop Y	0 m					_	_	_	_	_
🔽 Migrate	e whole Profi	le	Adjust	Step	2.5	m						
Time estima	ation settings	S	_	-				Aperture				
Sampling	5 m		-	V.				from	-1000	m to	-100	oup: m
Marcin	E0 m	® HV K	⊘∿		Gradient		0	🔽 to the	right of	source-re	eceiver g	roup:
Margin	50 m				<u> </u>			from	100	m to	1000	m
Threshold	0.1 s											
Output file	C:\Users\\$	Stefan \Desktop \Le	ismer model∖Mode	ling-Alex\Job-02	Processing Ec		V Offset I	Restrictions				
	ОК	:		Cancel			min(Xs-Xr)) -300	m ma	ax(Xs-Xr)	300	m

In the <u>Duplex Wave Migration</u> tab, the user will need to double check that the <u>Input file</u> is the correct SGY file, containing the appropriate synthetic seismograms and also specify the name as well as the location of the <u>Output File</u> (i.e. the migrated seismic section).

The DWM algorithm is designed to image the DW energy that will arrive at a time greater than that of the primary base boundary. A beam tube construction eliminates the migration noise that would result from the base boundary primary reflections in the migration summation. For this reason in the <u>Model P file</u>, the user needs to upload the SGY P wave velocity model (in depth domain), that contains just the horizontal and the sub-horizontal geological structures, without the vertical heterogeneities, that will ultimately be imaged by this method. The depth model can easily be generated by going <u>Model>Export to Seismic</u> Format (SGY) in the upper menu.

The user will also need to select the <u>Reflecting boundary (polygon</u>) or base boundary for duplex waves reflection. For exactly this reason the imported 2D model MUST at the very least have the base boundary as a polygon (see section 3.2). The base boundary should of course be below the sub-vertical heterogeneities that need to be imaged by DWM.

The migrated section is specified by the parameters <u>Start X</u> and <u>Stop X</u> as well as <u>Start Y</u> and <u>Stop Y</u> in the <u>Profile Coordinates</u> tab (whose direction can also be specified by the <u>Adjust</u> button). The parameter <u>Step</u> is recommended to be identical to the grid step that was used for forward modeling.

This program uses the eikonal solver to compute time fields. Discretization of the computation grid along the X and Z axis is specified by <u>Step</u> in the <u>Time estimation</u> <u>settings</u> group.

In the <u>Aperture</u> tab the migration aperture for duplex waves is assigned. The user can specify a left aperture by specifying the distance <u>to the left of the source</u> <u>receiver group</u> or a right aperture to the <u>to the right of the source</u> <u>receiver group</u>. Also, a symmetric aperture can be assigned by specifying both. The left aperture is to the left of the leftmost source/receiver in the observation system, while the right aperture is to the right of the rightmost source/receiver.

The signal stretching is limited by <u>Gradient</u>, whose default value is 0. If the gradient is too small, the images will be too "spread"; if the gradient is too big, some objects may disappear. There are two possible orders of reflections- <u>HV</u> and <u>VH</u> (i.e. reflection from the horizontal boundary followed by the reflection from the sub vertical boundary (HV) and vice versa (VH).

For offset restrictions use $\min(Xr-Xs)$ and $\max(Xr-Xs)$. Only the specified traces will be processed by DWM, the rest will be omitted. Please note that the specified values can be negative for traces to the left of the source and positive for traces to the right of the source.

<u>Threshold</u> is used for supressing the shot gathers by a particular time interval after the compressional direct wave arrival (if necessary!), in order eliminate unecessary migration noise.



10.5.4 2D Converted Duplex Wave Migration

Converted Duplex Wave Migration can be applied to PPS, PSS and PSP type duplex wave, as you can see in the <u>CDWM</u> window. And depending on the type of converted duplex waves, you may be required to use the X component (i.e. horizontal particle velocity) of the synthetic seismograms and also load the S Model File.

-pare inc	ner model	Modeling-Alex\Jo	b-02\ModelBC_	Base_CS - Edited	I +GathEP-Z.sgy		Reflecting bou	undary (poly	rgon)			
	⊚ m/s	⊚ ft/s	Component	:		•	Keg River			•	Гор	
odel P file	Desktop \L	eismer model \Moc	deling-Alex\Mod	elBC_Base_CS -	Edited -PQR.sgy							
odel S file	sktop\Leis	mer model Modelir	ng-Alex\ModelB	C_Base_CS - Edi	ted -PQR_R.SGY							
Orientation	n of Profile in	Plan										
Start X	2000	m Start Y	0	m								
Stop X	4800	m Stop Y	0	m								
🔽 Migrate	e whole Prof	ile	Adjust	Step	2.5	m						
Time estima	ation setting	e						Aperture				
Conclus			-		*			to the	left of so	ource-rea	eiver gro	oup:
Sampling	5 m	💿 ну 🤽	P ©	ин КР	Gradient		0	πom	-300	m to	0	m
Margin	50 m	· •	<u>e</u>	11.22				from	100	m to	1000	m
								📃 betwe	en souro	e and red	ceiver:	
	0.1 s	Sequence of v	waves migrated	PPS 🔻	(requires X-comp	ponent a	of seismogram)		5	m from	ı left poir	ht
Threshold				PPS						-		

The user also the option of specifying internal apertures (i.e. <u>between source and</u> receiver). This option should be used for the imaging of transmitted converted waves.

10.5.5 2D Duplex Wave Migration from Scattered Waves

The use DWM for scattered waves is most suitable for targets below the last strong reflecting horizon, such as faults, salt domes and other steep structure flanks.

nput file	ner model	Modeli	ng-Alex\Jol	o-02\ModelBC	_Base	_CS - Edited	+GathEP-2	Z.sgy						
	⊚ m/s	© ft	/s	Compone	nt 🗌			•			Depth in	terval	50	<u> </u>
1odel P file	Desktop\L	eismer	model (Mod	eling-Alex\Mo	delBC	_Base_CS - I	Edited -PQF	l.sgy						
Orientation	n of Profile in	Plan												
Start X	2000	m	Start Y	0	m									
Stop X	4800	m	Stop Y	0	m									
🔽 Migrat	e whole Prof	ile		Adjust	:	Step	2	m						
T		_								Aperture				
Time esum	ation setting	s		T		.				🔽 to the	eleft of s	source-	receiver g	roup
Sampling	2 m				8 . M I	4	^			from	-300	m	to 0	m
		۲	" <u>N</u>		U VH	Δ	Grad	lient	0	🔲 to the	right of	source	-receiver	group
Margin	250 m						Ó			from	100	m	to 1000	m
	And the	41		Inc. no	n esta		7 010000							
			0D-U 2\M00	PIRC Base C	s - Eau	red +Gather	-Z-DWMSW	SOV						

Unlike for DWM for PPP and converted waves, no base boundary is specified for this method. Instead, the <u>Depth interval</u> or the base boundary depth step for scattered duplex waves relative to the bottom off the model is specified. The automatically generated base boundaries are perfectly horizontal and they are computed for the entire model depth.



10.5.6 Depth 2D VSP Migration

To run 2D depth VSP migration choose <u>Run > VSP procedures (Depth</u> <u>domain) > 2D Depth Kirchhoff VSP Migration (PSDM)</u> from the menu. The next dialog will appear.

out file	C:\seis	_data\2D migr\up	o2.sgy					Gradient	0.5		
			Compone	ent			~				
del file								Min time sh from direct	ift wave 0.1	s	
								Vp/Vs	1.73264		
Profile co	ordinates				Output	section		Coordinates	s along Z-axis		
Start X	-1998.3	ft Start Y	0	ft	Start	7898.3	ft	Start Z		ft	
Stop X	7001	ft Stop Y	0	ft	Stop	8999.3	ft	Stop Z] ft	
			Adju	st	Step	47.6	ft	Step Z		ft	
îme estir Step Margin	200	s ft	Apertures for X-coordinate	horizontz (ft) Add Delete	al boundary	T (s) /	<u>N (ft) A</u> 0	v (tt) 0	⊠ ^{Wa} hori □ ^{Wa} ver	ves reflected izontal bound ves reflected tical boundar	i fro dary d fro
						Load		Save et Restrictions			
	[C]	ata\2D migr/up2-	PSDM-1 env				1000	wa [0	the many/Va	243 D	7.

The dialog automatically picks up a shotgather for migration from the current <u>Seismic</u> frame. (If the shotgather is not selected or does not fit, select another one using the button \dots). The output file will contain the migrated section. Its name is also automatically generated if the name of the input shotgather file is selected by adding the suffix "+ PSDM" to its name. If a file with the same name already exists, an additional version number is added (a digit from 0 to 9).

<u>Min time shift from direct wave</u> is used in order not to exclude the trace fragment of T0 times from t-s to t+s, where t is the first arrival time of the wave incoming from the source to the receiver, and s is the value of this parameter in seconds. (The value of t is automatically calculated for each trace according to the velocity model during the migration process.)

The checkboxes <u>Waves</u> reflected from horizontal boundary and <u>Waves</u> reflected from vertical boundary determine which borders to build in migration: (horizontal, or vertical); in our case, the borders are only horizontal, so select the top flag.

The <u>Start</u>, <u>Stop</u>, <u>Step</u> of the migrated section grid in depth (<u>Output Section</u>) are automatically determined from the velocity model (<u>Model</u> frame).

The spatial <u>Step</u> of the section grid (both in length and depth) in the <u>Time</u> <u>estimation settings</u> section may be different from the corresponding output section sampling (<u>Step</u> from the <u>Output Section</u>). The former is used internally for calculation of wave propagation times by eikonal algorithm. Its default value is estimated by a heuristic rule. A smaller step provides greater accuracy of the calculated times for the cost of quadratic deceleration. (I.e., the deceleration coefficient is of the power of 2 relative to the scale factor of the change in step). The <u>Margin</u> next to the <u>Step</u> is needed to weaken the influence of the edges of the model.

Each sample of the input seismogram trace is "smashed" within a cone (a triangle in 2D) which is defined by the migration apertures. For each trace, the triangle is plotted from the midpoint between the x-coordinate of the source (xs) and the x-coordinate of the receiver (xr).



The migration apertures can both vary along the recording time axis in the vertical direction T0 and depending on the position of the source. The default aperture values are selected so that the angle at the apex of the alpha cone is about 15 degrees. The ellipse arc shows at which points of the output section the trace value of the input seismogram will be summed over time t=ts+tr (= 1.715 in the next figures), where *ts* is the first arrival time of the down going wave from the source to media cell, and *tr* is the first arrival time of the upcoming wave from the media cell to the receiver.

		t:	= (t0 +	t1+t2	2)*2 = 1	715
Apertures for X-coordinate 8448	horizontal bour (ft) Add	ndary	T (s)	Al (ft)	Ar (ft)	-
	Delete Delete All	*	1.715 0	1610 0	1610 0	
			Load		Save	

_ . . _

The migration apertures can be different for different shotpoints. If there is just one aperture X-coordinate, the aperture is used for all traces (and so its X is ignored).

Having completed entering the migration parameters, click \underline{OK} to start the migration calculation and get the result.



10.5.7 Depth 3D VSP Migration

To run 3D depth VSP migration choose <u>Run > VSP procedures (Depth</u> domain) > 3D Depth Kirchhoff VSP Migration (3D PSDM) from the menu.

Please note that only migration of P waves reflected from horizontal boundaries has been implemented for this method.

nput file	'SP all sho	ts \DUR	PLEX_VELO	CITY_MODE	L_new	sort_rever	s+Gath3DA	PUz.sgy		Gradient	0.5	
	⊚ m/s	⊚ f	ft/s	Compor	nent				•		0	1
Model P file	e C:\User	s\Stef	an \Deskto	p\Tesseral te	sts\3D	VSP Mode	elling test\3D	VSP all sl	n	Time estimation	on settings	
Model S file	2									Step X/Y/Z	5	m
Output cub	e									Margin	50	m
X00	446.4	m	Y00	1259	m	Step X	50	m				
Xx0	3022	m	Yx0	379.8	m	Step Y	50	m	Apert.	ires T (s)	Radius (m)	
ХОу	-145.9	m	YOy	3979.8	m	☑ [Rotated Axe	:S	*	0 1.801 0	0 1090 0	
Start Z	0	m	Stop Z	4070	m	Step Z	5	m	(Load	Save]
Dutput file	C:\Users\	Stefar	Waves r horizonta	eflected from al boundary Tesseral test	s\3D V	'SP Modellir	ng test\3D V	SP all sho	Min from	time shift n direct wave	0.1	s

<u>Input file</u> -3D seismogram file. If the file type is TGR (as opposed to SGY) it is necessary to specify the Component of the data file that is to be processed.

Next you must load the depth $\underline{Model P}$ file and specify the size of the output migrated cube.

The output (imaging) area is rectangular. And there are two ways to define this rectangle:

- In general case the output rectangle is defined manually by coordinates of 3 sequential corner points: $\underline{Xx0}$, $\underline{Yx0}$, $\underline{X00}$, $\underline{Y00}$, $\underline{X0y}$, and $\underline{Y0y}$ in the <u>Rotated Axes</u> group. Approximate values may be used. The program adjusts the coordinates to form a true rectangle.



- If the output rectangle boundaries are parallel to coordinate axes it can be alternatively defined by the parameters: <u>StartX</u>, <u>StopX</u>, <u>StartY</u>, and <u>StopY</u>. The program supports output of vertical sections, so combinations like <u>StartX=StopX</u> and StartY=StopY are enabled.

<u>StartZ</u>, <u>StopZ</u> is depth interval of the output array. <u>StopZ</u> must be below (bigger) then boundary depths of the model file.

StepX, StepY, StepZ are the grid steps for the output array.

To specify the circular aperture explicitly enter directly the $\underline{T(s)}$ and $\underline{Radius(m)}$ in the Apertures group. If the migration aperture is not specified, the program uses default values.

Min. time shift from direct wave(s) is used for muting VSP gathers by a particular time interval in order to eliminate the migration noise associated with the direct wave arrival.

The rest of the parameters in <u>Depth VSP Migration</u> window are exatly the same as for 2D Time/Depth Pre-Stack Kirchoff Migration (Please see section 10.5).

10.6Post-Processing

Procedures for post-processing of seismic data:

10.6.1 Trace-wise Procedures

One Trace Procedures	1 4 4	x
Input file C:\Users\	Stefan\Desktop\Export_to_seismic_format_test\Test-1+Ga	ith/
🔲 Zero Balancing	window lenght 0 ms	
🗌 Linear Gain	top gain 1 bottom gain 1	
Normalization	align traces by energy	-
🔲 Auto Gain	window lenght 0 ms noise 0	%
Add White Noise	standard deviation of noise 0	%
🔲 Random Shift	standard deviation of shift 0	ms
Smoothing	window length 0	ms
🗌 Shift	length 0	ms
Final Scaling	magnitude 100 % offset 0	
Output file C: Users (Stefan Wesktop (Export_to_seismic_format_test\lest-1+Ga	stn/
	ОК	Cancel

Check a box to apply the function to all the traces.

• Zero Balancing for balancing the traces to zero average value.

• <u>Linear Gain</u> is for increasing the amplitude of the top (<u>top gain</u>) or bottom (bottom gain) parts of the traces.

• Normalization is to normalize a trace using one of selected criteria.

• <u>Auto Gain</u> is to smooth the trace automatically. The parameters of such smoothing may be: <u>window length</u> is the time (or depth, metrical) interval for which the smoothing is carried out, <u>noise</u> is a threshold (noise threshold in percent of the maximal amplitude) and outside this threshold smoothing is suppressed.

• Add White Noise (in percent of the maximal amplitude) is to add white noise to the traces.

- <u>Random shift</u> is to add a random shift to the traces.
- Smoothing is to cut out the high frequency noises, if they are in the image.
- <u>Shift</u> is to shift the whole trace up or down along the time direction.

• <u>Final Scaling</u> (in percent of the maximal amplitude) is to change the absolute value of the amplitudes.

10.6.2 Zero seismic cube above surface

With the help of this function the user can mute any given 3D seismic cube above the specified horizon. To implement this function first of all load the SGY cube $\underline{File>Load}$ seismic file...

odel A-1.tpa - TesseralPro	o Madal Mar	Crimin 201	Carry Dara	Hala																				- 0
Database Edit View	× <u>Model</u> M <u>ap</u> ≃ 12≊ SS [2]		view <u>K</u> un	Help	<u>0</u> 0	Q Q Q	100%	•	P 🖬 🗌	N?														
🗙 🖸 🔁 🚍 %	% % 0		0	*	. 🔍 🕀		<u>₹</u> =	÷ •	₩ # 0) 🗗 [7 = 🔁 2	5 🔊 🐳	6											
N Press										·····		A	*******		*******	*******			*****	******	********			********
35	00 3600	3700	3800	3900	4000	4100	4200	4300	4400	4500	4600	4700	4800	4900	5000	5100	5200	5300	5400	5500	5600	5700	5800	5900
	· · · · · · · · · · · · · · · · · · ·	*****			• • • •	• • • •	• • • • •	• • • • • •			•••••	*****	****	*****	• • • • • • •		****					• • • •		
X 100	0 200 300	400 500	'eoo '7	700 800	900	1000 111	00 1200	1300 14	00 1500	1600 170	0 1800	1900 2000	2100 2	200 2300	2400 2	500 2000	2700 21	100 2900	3000 310	0 3200	3300 340	0 3500	3600 3700	3800 3900
Len 0	100 200 30	0 400 50	00 600	700 80	0 900	1000	1100 1200	1300	1400 1500	1600	1700 1800	1900 201	0 2100	2200 23	2400	2500 26	0 2700	2800 290	0 3000	3100 3200	3300	1400 3500	3600 370	0 3800 31
1000																								
1500																								
2000																								
2500																								
3000																								
3500																								
<																								
seismograms creating:	STEP 1: Create	Velocity Model >	STEP 2:	Acquisition Ge	ometry >	STEP 3:	Run modeling	>	Hide															

...followed by <u>Run>Post processing>Zero Seismic Cube above a</u> <u>surface</u>.

Zero seismic cube abo	ove a surface		×
Input			
Seismic cube	C:\Users\Stefan\Desktop\Tesserral Pro testing new version\		
Surface map	C:\Users\Stefan\Desktop\Tesserral Pro testing new version\	3D Model building tes	
Layer height	800 m		
Output			
Output cube	C:\Users\Stefan\Desktop\Tesserral Pro testing new version\	DUPLEX_VELOCITY_N	
	_		
		OK	ncel

Make sure the correct cube has been loaded in the <u>Seismic cube</u> dialogue, then load the <u>Surface map</u> (i.e. the horizon) and specify the <u>Layer height</u>, which is the distance above the horizon of the specified <u>Seismic cube</u> that should be preserved.

Untitled - TesseralPro								💼 US	😰 Help Ţ						0 X
	₩ <u>Model</u> Mgp <u>seam</u> c so view <u>Fun</u> <u>Hep</u> ₩ <u>15</u> SS [7] /9 [1] [3] [7] [3] [3] [3] [3] [3] [3] [3] [3] [3] [3														
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									В						-
	DUPLEX VELOCITY MODEL newsor revers say			_			4000		Zero 500at	ove sgy	6000	6000	6400		
9-55 S	300 3800 4000 4200 4400 4600 4800 5000 5200 5400 5600 5800	600	Ϊ.	3	600 380	0 4000	4200	4400	4600	4800	5000	5200	5400	5600 5800	6000
······································			1												<u> </u>
× 2	200 '400 '600 '800 '1000 '1200 '1400 '1600 '1800 '2000 '2200 '2400 '2600 '2800 '3000 '3200 '3400 '3600 '38	00	×		200 400	600 800	1000 1200	1400 1	800 1800	2000 2200	2400 20	500 2800	3000 3200	3400 3600 3	800
Len 0	200 400 600 800 1000 1200 1400 1800 2000 2200 2400 2800 3000 3200 3400 8600 1	1800	Ler	0	200 400	'eco 'soo	1000 12	1400	1600 1800	2000 2200	2400 2	2000 2800	3000 3200	3400 3600	3800
			1	-											
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			1	-											
1000		1000	100	-											1000
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			1	-											+ -
2000		2000	200	-											2000
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			+	-											+ -
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< + <			1	_											- • Ť
Synthetic seismograms creating:	STEP 1: Create Velocity Model > STEP 2: Acquisition Geometry > STEP 3: Run modeling > Hide														
point: 174 x 201 mm,	1 frames selected														
10.6.3 Zero seismic cube under surface



With the help of this function the user can mute any given 3D seismic cube below the specified horizon. To implement this function first of all load the SGY cube <u>File>Load seismic</u> file...

...followed by Run>Post processing>Zero Seismic Cube under a surface.

Zero seismic cube uno	der surface
Input	
Seismic cube	C: \Users\Stefan \Desktop \Standard training material \2D and 3D ray tracing \3D Ra
Surface map	C:\Users\Stefan\Desktop\Standard training material\2D and 3D ray tracing\3D Ra
Layer height	300 m
Output	
Output cube	D Ray Tracing files \DUPLEX_VELOCITY_MODEL_newsort_revers_crop_under.sgy
	OK

Make sure the correct cube has been loaded in the <u>Seismic cube</u> dialogue, then load the <u>Surface map</u> (i.e. the horizon) and specify the <u>Layer height</u>, which is the distance

above the horizon of the specified Seismic cube that should be eliminated.



11 Frames

In this section, the general guidelines for manipulating different Frames are presented.

Tesseral Pro supports 4 types of Frames – model, surface, gather and 3D-view. The parameters for a Frames' display can be customized in the dialogue box and with the help of the options in the corresponding menu. Frames can be deleted, moved and duplicated. Operations with one or more Frames are supported as well. A Frame can be printed or exported to an exact vector (raster-type) picture (WYSIWYG technology). There are the two main modes to display Frames: Document view and Tablet view. More information can be found below.

11.1 Frame types

The Tesseral Pro program supports 4 types of Frames:



• <u>Model Frame</u> (Model) is the Frame in depth. Model is always created in depth. The velocity model is formed by polygons based on the well logging and/or seismic data. The polygons are created by the user manually or automatically from the map of stratigraphic horizons (see Section 14.2.7). Information related to velocity, density and anisotropy or fracturing can be entered in each polygon. The polygon parameters are set manually in the dialogue box or may be loaded from the well logging data for selected wells (thin layering). Information about shot and receiver points is also entered into the model. The built velocity models with shot-receiver layouts are used for calculation of the synthetic gathers. For more details about the Model Frame, please see Section 3, 4, and 12.

• <u>Map Frame</u> (Map) is the Frame where the map of the wells location within the field and the map of the surface calculated by the well data or imported from external text files are displayed. The information needed for calculation of the surfaces, namely the coordinates of the layers and the wells intersections, should be loaded to the database in advance. Tesseral Pro has 9 methods for map generation, such as spline-approximation, Kriging and multiple regression. The cross-section model (Model Frame) for any section traced in the map is built automatically on the basis of the calculated (loaded) surfaces. More details about the Map Frame can be found in the Section 14.

• <u>Seismic Frame</u> (Seismic) displays gathers in SEG-Y, SDS-PC, and TGR formats. 3D gathers display also is supported. Please see Section 13 for details about the Frame Seismic.

• <u>3D View Frame</u> is for visualization of 3D images. Please see Section 15 for details about the 3D View Frame.

To create a new frame, use the command $\underline{File} > \underline{New}$ \underline{Frame} . After that, in the dialogue box of the frame parameters, the default values may be changed.

Each type of frame has its own 2 headers (the upper and the lower one). In the upper header, any text is displayed (by default, the upper header looks like the header of a pane in Windows), and the lower header contains special information specific for each type of Frame.



NOTE: Double click on the header of any frame to "expand" this frame to the whole window size (equivalent to the command <u>View</u> > Frame Full Screen). The repeated double click on a frame header arranges frames in form of "grid" inside the window (equivalent to the command View > Arrange Frames).

11.2 Frame Selection

Please use the left mouse button to select a Frame from the document field. The selected Frame will be shown inside a dotted rectangle. To cancel the selection, click outside the Frame boundaries using the left mouse button. The selection or de-selection of several Frames is implemented by the standard method for Windows. To select several Frames, please use the left mouse button together with the Ctrl or Shift key.

Also in the <u>Document View Mode</u>, you can select a group of Frames by pressing the left mouse button outside the Frames on the blank field of the document and then dragging it (while pressing the left mouse button) to create a rectangular area. All Frames that fall inside this area will be selected.

The last Frame selected is assumed to be the main Frame, and all the individual (nongroup) commands will be applied to it. To change the selection of a Frame, click on it with the left mouse button while holding the <u>Shift</u> key. To select a Frame as the main one, please click on it with the left mouse button while holding the <u>Ctrl</u> key.

To select all Frames at once, please use the command $\underline{\text{View}} > \underline{\text{Select All}}$ Frames, and to de-select all the Frames, use the command $\underline{\text{View}} > \underline{\text{Deselect All}}$ Frames.

11.3 Frame layout

In order to move a Frame within the Tesseral Pro main window, please press and hold the left mouse button on the upper headline of the Frame and just drag it. There are two modes of Frame layout.

1. View > Document View Mode – Frames are freely distributed in the document.



In this mode, the Frames can overlap each other, therefore the commands $\underline{\text{View}} > \underline{\text{Bring Frame Forward}}$ and $\underline{\text{View}} > \underline{\text{Bring Frame Backward}}$ are used to set the right visualization order.

2. <u>View > Tablet View Mode</u> – Frames are only distributed in table cells. To change the size of any cell, please drag it with the mouse (while holding the left mouse button) from any Frame side, or change the size of the column (row) of the table in the internal axis of the Frame window.

If you drag a Frame into a cell used by another Frame, the old Frame will be moved to the nearest free cell.

NOTE: Please use the command <u>View > Arrange Frames</u> to sort the Frames automatically according to the sizes of their windows. For an easier way to work with selected Frame, please use the command View > Frame Full Screen.

11.4 Frame size

The width and the height of the Frames are adjusted in the dialogue box $\underline{Edit} > \underline{Edit}$ <u>Frame Properties</u>. The height of the upper and the lower headers is defined in the dialogue boxes of the upper and the lower headers, respectively. For the Frames displayed in depth or time scale (Model and Seismic), the height and the width are calculated automatically from the top, bottom and scale information. The sizes of the Frames may be changed by the mouse, which can be done by dragging the Frame's borders while pressing the left mouse button. While several Frames are selected, the changes will be only applied to the main (last) selected Frame. The size of the remaining Frames will be the same. The height and the width of the upper and the lower headers will be changed by pressing and dragging the lower headline border.

NOTE: It is possible to change the top and the bottom of any Frame with the scale by dragging the top or the bottom with the Ctrl key pressed.



The next picture shows the different ways to change the Frame parameters

NOTE: While changing the Frames' sizes in the Tablet View Mode, the sizes of all Frames in the same table row and column are also changed.

11.5 Undo/Redo

Working with Frames, you may undo any action (or sequence of actions) using $\underline{Edit} > \underline{Undo}$. To redo the action that you've undone, please use $\underline{Edit} > \underline{Redo}$. Commands \underline{Undo} and \underline{Redo} are not supported while working with files (menu <u>File</u>), database (menu <u>Database</u>) and calculating and editing seismic surfaces (<u>Map > Add New Horizon from Well</u> <u>Tops</u>, <u>Map > Manage/Delete Maps</u>, <u>Map > Active Map</u>).

11.6 Scale of display

To scale the document (zoom in/out), please use the command $\underline{\text{View} > \text{Zoom}}$ or the scaling buttons in the main toolbar.

						Buttons fo	or zoom
nic <u>R</u> ur	n <u>H</u> elp 🗗 = 🔣 🏹 🛪 🕫		€ Q @ ■ %) 100%			-
						А	
		******		**********	*********	Model	
2000	2050	2100	2150	2200	2250	2300	

11.7 Print and export

Documents are created on the principle of WYSIWYG by using Frames. For more details, please see section 11.3.

Please use the command <u>File > Print</u> to print a document.

Apart from printing, documents can be exported as a picture in any of the following formats (TIFF, EMF, WMF and BMP) by using the command File > Save as Picture.



11.8 Project tree and the database

After the new project is saved (command <u>File > Save Project</u>), or after loading of an old project, in the left window of Tesseral Pro, the tree of the opened project is shown. This tree helps to systemize all loaded and created files.

The point is that, during the modeling of synthetic gathers, several files are created and they are all located within the same folder (please see details in the Section 5.4). Additionally, after launching several jobs for the same model using different modeling techniques, more sets of output files are created. All these files are located in the same folder, and it may be complicated to find the needed one. The project tree will simplify this task. The branches in the tree have the same names as the corresponding modeling method (Acoustic, Elastic, etc.). The remaining seismic files, which are created, for instance, by procedures of gather processing, are located in the branch <u>Seismic files</u> of the project tree. A double mouse click on a file in the project tree will create a <u>Seismic Frame</u> for this file in the right window of Tesseral Pro.

The branch «Database» connects to the Tesseral Pro database (please see details in the Section 17).

🚱 🔍 🛛 🕨 Computer 🕨 Loca	I Disk (C:) → Sheldon → TestingOfTesseralPro	▶ Run	✓ ⁴ y Searce	h Run
Organize 👻 Include in library 🔻	Share with 🔻 🛛 Burn 🛛 New folder		8=	- 1 0
🗼 Downloads 🔷	Name	Date modified	Туре	Size
🖳 Recent Places	Md2.tpa	2/15/2013 10:11 AM	TesseralPro Docume	744 KB
	Md2+GathAP.sgv	2/15/2013 10:10 AM	SGY File	326 KB
🥽 Libraries	Md2+GathAP.sgy.cr0	2/15/2013 10:10 AM	CR0 File	6 KB
Documents	Md2+GathAP.tgr	2/15/2013 10:10 AM	TGR File	881 KB
J Music	Md2+GathEP.sgy	2/15/2013 10:11 AM	SGY File	326 KB
Pictures	Md2+GathEP.sgy.cr0	2/15/2013 10:11 AM	CR0 File	6 KB
📑 Videos 😑	■ Md2+GathEP.tgr	2/15/2013 10:11 AM	TGR File	1,175 KB
	🖬 Md2+SnapAP.tgr	2/15/2013 10:10 AM	TGR File	41,308 KB
Computer	Md2+SnapAP.tgr.cr0	2/15/2013 10:10 AM	CR0 File	17 KB
Elocal Disk (C:)	🖬 Md2+SnapEP.tgr	2/15/2013 10:11 AM	TGR File	165,545 KB
ji deli	Md2+SnapEP.tgr.cr0	2/15/2013 10:11 AM	CR0 File	29 KB
An example of a folder	Md2+WaveAP-1.tgr	2/15/2013 10:10 AM	TGR File	8 KB
with results of Acoustic	Md2+WaveEP-1.tgr	2/15/2013 10:11 AM	TGR File	8 KB
and Elastic modeling	📕 Md21.tam	2/15/2013 10:11 AM	TAM File	16 KB
Program Files (x86)	i≝ Md22.tam	2/15/2013 10:11 AM	TAM File	16 KB
ProgramData	Md23.tam	2/15/2013 10:11 AM	TAM File	16 KB
Sheldon	Md24.tam	2/15/2013 10:11 AM	TAM File	16 KB
Tesseral Data	Md25.tam	2/15/2013 10:11 AM	TAM File	16 KB
Tesseral Technologies	Mod2D.log	2/15/2013 10:11 AM	Text Document	9 KB
UserDocs_Tesseral 🗸	🚛 runtask.ini	2/15/2013 10:11 AM	Configuration settin	1 KB
20 items				

Some branches of the project tree are the frame branches (Model, Surface, and Seismic). Double click these items to maximize the corresponding size in the window on the right.

12 Model Frame

The <u>Model</u> Frame is used for creating depth velocity models using polygons, well data, underlying seismic images (2D or 3D models). After that, the velocity depth model is used for calculating synthetic gathers.

Please see:

- Section *3* for details about model creation
- Section 3.2.9 and 17.5 for using well data
- Section 3.1.10 about filling of a model with polygons, Section 4 about creation of the acquisition geometry
 - Section 5 about launching job of modeling a synthetic gather
 - Section *13* about displaying computed gathers, seismic models and field gathers Please see below for some additional features about using the Model Frame.

12.1 Properties of the Model Frame

To invoke the dialogue box with properties for an existing Model Frame, please select the command Model > Model Frame Properties.

Model Properties		Select	well data to be used	X
Top title		Palette	H	orizontal scale
Bottom title Height (mm) 13	0	Font		Vertical scale
	Depth interval	ckground	Bo	rehole
	Top -400	ft	- Left side	Right side
Delete <	Bottom 17000	ft	Layers	Layers
Delete all << Set depth interval	Scale 1 133846	•	Scale	C Scale
,			Background	Background
Zoom map Draw section manually	Section interval		Individual	well properties
	Lenght 10000	ft		
12 8	Azimuth 218.3		Component Compr	ession Velocity 💽
⇒ °1 = Select a section	icale 1 88496	•	Base se	eismogram
	×beg. 15430.0	ft	Base	picture
10000 15000	Y beg. 15883.0	ft		Cancel
	L	Adjust	seismic underlay	

All the parameters input via the model building Wizard, may be changed manually in the dialogue box <u>Model Properties</u>.

To select wells for the model – Please click the button Add >.

Select Wells	×
Field	
[65535] General (m) [65535] Gorobcivskoje (ft)	
y Wells	
1 10 11 12 13 14 15 16 17 18 2	E
20 21 22 23 24 25	OK Cancel

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To select a section line – along which the model section will be created. After checking the option <u>Draw section manually</u>, in the lower left corner of the <u>Model Properties</u> dialogue box, you can draw the section line by using the mouse by pressing-dragging-releasing. To define the section line more precisely, you can: A) Select the origin coordinates, the azimuth and the length of the line in the <u>Section interval</u> group; or B) Click the <u>Zoom map</u> button to load the map for visual input.



To set depth interval – In the <u>Depth</u> interval group, please specify the top and the bottom of the model.

To select the data to be displayed for the well - In the <u>Well data</u> group,



Left side – The data to be displayed on the left side of the well bores

<u>Right side</u> – The data to be displayed on the right side of the well bores Please select the type of well data you want to display.

 \underline{Log} – The well log data. From the dialogue box of the well log parameters, please select the logs you want to display. For more details, see the Section 3.2.10.

12.2 Model re-size

The command $\underline{Model} > \underline{Scale}$ is used.



Using this command, you may change the size of the model by stretching or compressing all polygons and location of sources and receivers consistently, which is done by specifying the parameter <u>Re-size model by Scale</u>.

NOTE: If you like to change the measurement units for the whole project (<u>ft to m</u> or <u>m to ft</u>), it is recommended to use the command <u>File > Project Properties</u> (please see details in the Section 16).

If the parameter \underline{Length} , \underline{Top} or \underline{Bottom} is changed, the polygons of the model will not be stretched nor shifted.

12.3 Model export

It is possible to export a model to any of the 3 seismic formats (TGR, SDS-PC or SEG-Y), and to a TAM format used by Tesseral 2D.

12.3.1 Model export to a seismic format

Please use the command Model > Export to Seismic Format (SEG-Y, TGR).

Seismogram calculation	— ×
Seismic file name	Fit file name
C:\Tesseral Technologies\Tesseral Pro\Mod	del.sgy 📃 🛄
Sampling Rate	
Step by length 50 m	
Step by depth 50 m	
Export Medium Anisotropic Properties	OK
Components: value range	Cancel

Co	Components: value range						
	Component	Units	Min value	Max value			
	Compressional velocity	m/s	100	10000			
	Density	kg/m^3	1000	3800			
	Shear velocity	m/s	0	6000			
			OK	Cancel			

In this dialogue box, please specify the cell size, the name of the output file. The minimum and maximum values of each component in the <u>Components: value range</u> <u>window</u> are to limit the possible spikes after interpolating the well log data.

NOTE: If the TGR file contains multiple components or if you export a model in SDS-PC or SEG-Y formats, then 3 files will be generated (one file for each component). File with the selected name will contain the data of <u>Compressional velocity</u> (**<file name>**– **PQR.sgy**), <u>Density</u> (**<file name>**–**PQR_Q.SGY**) and <u>Shear velocity</u> (**<file name>**– **PQR_R.SGY**).

After creating these files, a Seismic Frame should appear in the Tesseral Pro window to display the gathers created from the model.

Please see results



NOTE: The acquisition parameters data are not exported when model is exported to any seismic format.

12.3.2 Model export to Tesseral 2D (TAM format)

Please use the command Model > Export to Tesseral 2D Format (TAM).



While the model is being exported to TAM file, the thin layering data is not exported, but the acquisition geometry data is exported.

13 Frame Seismic

This is the frame to display files in SEG-Y, SDS-PC or TGR formats. The frame is to support displaying 2D/3D field and synthetic gathers, models, migrated slices/cubes, VSP gathers, multi-component files, snapshots of wave field propagation, etc.

13.1 Load seismic files

The seismic files are loaded by using the command $\underline{\text{Seismic}} > \text{Load Seismic}$ <u>File (New Frame)</u> (Seismic). If several files are loaded at once, then they will be displayed in the joint coordinate space.

If a seismic file is opened for the first time, it is proposed to select its type to apply the appropriate display mode, as shown below.

Select type of seismic data			×
Please select the typ	e of seismic	data in file	
Field	Data.sgy		
Model or Migrated gather	Gather	VSP	Raw Traces
			I don't know

Your selection will determine the displaying mode (please see Section 13.2), which can be changed at any time by using the <u>View Mode</u> command on the <u>Seismic</u> menu or the button from the toolbar.

After that, your seismic file will be read. If a file is opened for the first time, it may take a long time to create the index files of the trace coordinates, which will be used later for optimizing the display.

The Frame Seismic represents a rectangular graphic object which includes the images of the source/receiver spread (above) and the traces (below). On the edge of the frame, the scale for the X/Y/Z axis is displayed. On the top, the color palette of the trace values is shown:



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In the source/receiver spread, the positions of sources (small squares) and the coordinates of traces (small crosses) are shown. The current source is marked in red and its coordinates are shown in a balloon. The trace view may include the wiggle of the trace and the images corresponding to the palette. The coordinates of the sources and receivers in the spread may be displayed differently. These settings can be changed in the Frame Properties dialog, which is called by the button (\checkmark) (please see the Section 13.8).

While moving the mouse cursor in the sections area (the vertical or the horizontal slice), the mouse cursor's coordinates and the corresponding trace value are displayed in the status bar.

Z=5185.9 ms Value=493.0 X=768640.0 m Y=997660.0 m

13.1.1 Plan view



The positions of the sources are always displayed as small squares, but the way of displaying the receiver's position depends on the display mode. For the seismic data with a small number of traces, the receiver's position is shown as crosses. For large gathers, the receiver's position is shown as grey dots. For very big gathers or cubes, the receiver's position is shown as contours.

13.2 Trace display

In Tesseral Pro, there are several modes to display traces, and each of the modes is suitable for a specific task and type of seismic data. To preview gathers, 3 modes are commonly used, as illustrated in the figure below (from left to right: "Show All Receivers", "Show Current Shotgather" and "Show as VSP").



1. In the <u>Show All Receivers</u> mode, the spread of all the sources and receivers is shown in the top view. This mode is used if you want to have an overview of the whole field under study, and also get the sections of trace profiles belonging to several different sources.

2. The <u>Show Current Shotgather</u> mode is for displaying shot gathers. Only the traces of the current source are shown. It can also be used to show the traces of the chosen receivers along any profile.

3. The <u>VSP</u> mode is used for visualization of the VSP traces. The sources are located vertically (usually inside a well) and the traces are shown from left to right.

13.3 Operations with Seismic Frame

While working with the <u>Seismic</u> Frame, 4 Edit Modes can be used: <u>Select Source Mode</u> ([№]), <u>Draw Profile Mode</u> ([∞]), <u>Zoom Mode</u> ([∞]) and <u>Move Mode</u> ([⊕]).

The <u>Select Source Mode</u> allows selecting an active source and this source will be marked in red on the acquisition surface and its coordinates will be shown in a balloon. The <u>Draw</u> <u>Profile Mode</u> allows selecting the vertical section by drawing a line on the top view. In this case, the receivers will fall into the section if their distance to the profile is less than the given one (this distance is computed automatically during the opening of the seismic file, but it may be changed in the settings). In the <u>Zoom Mode</u> and the <u>Move Mode</u>, it is possible to zoom in and drag both the acquisition surface and the vertical section.

Let's describe each of the modes for displaying seismic files.

• <u>"Select Source Mode</u>" (*)) enables to show the current source and its corresponding traces.

• "Draw Profile Mode" (\square) enables to draw a profile manually in the top view. Please see Section 13.5 for more details. Additionally, in this mode, a horizontal section can be shown.

• " $\underline{\text{Zoom Mode}}$ " (\mathbb{Q}) enables to enlarge the image for the given area.

• "Zoom In" (*[‡]) enables to enlarge image.

• "<u>Zoom Out</u>" (⁺⁺) enables to reduce image.

• "Zoom 100%" (^E) enables to zoom out the image fully.

• " $\underline{\text{Zoom }}$ " opens a dialogue box to set the zoom parameters.

• "<u>Rescale to Make X Scale = Y Scale</u>" (²) changes the Frame sizes so that the proportions of the geographic coordinates in the top view correspond to the visual ones.

• "<u>Rescale to Make X Scale = Z Scale</u>" (D=) changes the Frame sizes so that the proportions of the geographic coordinates of the traces correspond to the visual ones.

• "<u>Normalize Palette by Visible Data</u>" (¹) fixes the maximum and the minimum in the color palette to match the minimal and maximal values in the data currently visible in the Frame.

• "<u>Normalize Palette by All Data</u>" () fixes the maximum and the minimum in the color palette to match the minimal and maximal values in the seismic files currently loaded in the Frame.

• "<u>Show Component</u>" enables to select the components to be displayed (for the TGR format).

• "<u>Next/Previous Shotpoint</u>" () enables to set next/previous source as the current source.

• "<u>Export Traces Coordinates</u>" enables to export the trace coordinates to a text file.

• "Import Traces Coordinates" enables to import the trace coordinates from a text file.

• "<u>Refresh</u>" (⁽²⁾) re-load the data in the Frame (re-read all the data from the seismic files).

• "Apply Settings to all Seismic Frames" (2019-2021

settings of the current Frame to other Frames.

Furthermore, the user can display the amplitude spectrum for any area of the seismogram by clicking on <u>Spectrum Mode</u> and selecting the region for which the amplitude spectrum is to be calculated. To select the region simply hold the left mouse button, move the mouse to draw the region and release the left mouse button. To obtain the amplitude spectrum for a different region simply select a different region using the same procedure.





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13.4 Preview of 3D seismic models or 3D migration results

Users can preview the 3D raster cubes in the <u>Seismic</u> Frame using the mode "<u>Show as</u> <u>Model</u>" () and forming horizontal and vertical slices along any user-defined profile. As such cubes are in the format of seismic data, the cube's content is in form of traces. In this case, to describe the X and Y coordinates, the coordinates of the trace's receiver are used, and the Z coordinate is determined from the trace itself. In the general case, the coordinates of the source are ignored, but for compatibility with the seismic data preview tools, it is more suitable either to suppose that the source coordinates are equal to the receiver coordinates, or to create one source for the receivers having Y=const (this is implemented in Tesseral Pro), for which the X coordinate will be equal to the minimal X coordinate of receivers.



13.5 Profiles

The easiest way to create a profile is to switch to "<u>Draw Profile Mode</u>" (\square), then draw the line manually on the top view, only those traces whose distance to the profile is within the pre-defined value specified in the object's properties will be included into the section. If the pre-defined distance is too large, the traces outside the profile will be displayed. If the pre-defined distance is too small, fewer or no traces will be included into the section.

Section properties

The detailed properties of the profile are specified by choosing the menu <u>Seismic ></u> Section Properties.

Seismic Properties	— ×-
Common Units Layout Profile Zoo	om Rulers
Vertical section (Profile)	5 m Y 4112 m 36 m Y 1218 m
Length 4673.8 m Azimuth -38 deg	Finder-circle (max distance from profile line to trace) 35 m Distance fitting
Horizontal slice Draw color map Start: Z 1394 m End: Z 1394 m	© Straight (Z=const)
	Line Style K Cancel Apply Help

In this box, the profile coordinates, its length and azimuth may be defined, as well as the maximum distance between profile and a trace.

A vertical section may be exported to a separate seismic file, which may be then used as an underlying image for a model. The menu <u>Run > Seismic Frame > Export</u> Section to 2D Seismic File is used.

The seismic data loaded into a Frame may be rotated along the profile, by using the menu Seismic > Rotate to Align X Axis along Section Profile. But the content of the actual seismic files will not be modified as the rotation will only modify the corresponding auxiliary files with suffix ".cr0".



13.6 Overlay surfaces on seismic cubes

You may load a surface and obtain the intersection line between this surface and a 3D cube. To do this, please specify the <u>Seismic</u> Frame's properties and specify the name of the file containing the surface.

Seismic Properties	×
Common Units Layout Profile Zoom	Rulers
Vertical section (Profile)	m Y 0 m
End: X 0	m Y 0 m
Length 0 m	Finder-circle (max distance from profile line to trace) 35 m
Azimuth 0 deg	Distance fitting
Horizontal slice	
Draw color map	Ourvature Straight (Z=const)
Start: Z 0 m	From grid/surface file
End: Z 0 m	C:\Users\Stefan\Desktop\INPEX tra

Tesseral Pro supports loading surfaces in the following formats: XYV, CSV, DAT, Surfer, Schlumberger, Triple TXT, ZMap, Paradigm, GeoQuest, Landmark, Charisma-YX, Charisma-XY, ASC.



The intersection line between the surface and the cube is shown as dark green line in the vertical section.

While working in the <u>Profile Drawing</u> mode, when you click an arbitrary point on the vertical section, then a horizontal section will be created automatically such that it runs through the chosen point and is parallel to the loaded surface. This image will appear in the top view.

13.7 Horizontal sections

Tesseral Pro implements a rather unconventional (for other gather-viewing software) mode for displaying horizontal slices. This mode is useful for 2D visualization of the raster 3D cubes.

In the figure below, the horizontal (above) and the vertical (below) sections of the raster 3D velocity model are shown. In these sections, the profiles lines are shown, along which the horizontal/vertical sections were created. The profile line in the horizontal section is for creating a vertical section, and vice versa.



To build a horizontal section, just switch to the drawing mode and click on an arbitrary point in the vertical section. Then, the horizontal section passing through the given point will be created automatically and displayed in the top view (see the top image). If a vertical line is drawn in the vertical section, a horizontal section will be created, whose value at each position is the average value spanning the drawn line (see the bottom image). The area, for which the horizontal section is created, will be shown by hatching.

To remove the horizontal section while in the drawing mode, please click an arbitrary point in the vertical section while pressing "<u>Ctrl</u>" button.

13.8 Settings for Seismic Frame

The majority of the visualization options can be accessed in the <u>Seismic</u> Frame settings. The parameters for displaying gather are specified in the <u>Seismic Frame Properties</u> tab under the <u>Seismic</u> menu.

The properties dialog box is divided into several tabs. In the "<u>Common</u>" tab, the general properties for the visualization of the object are specified, and in the "<u>Layout</u>" tab, where the parameters for visualization of the acquisition surface are defined.

The <u>Units</u> tab in the <u>Seismic Properties window is</u> for changing (scaling) the coordinates and values of the trace data in case a gather is displayed incorrectly in the Frame. In this case, the original file is not modified, and the changes are saved into an additional file **<seismogram_file_name>.cr0**. These new modified values will be loaded next time the file is opened.

Seismic Properties			×
Common Units	Layout Profile Zoom	Rulers	
Seismic File Prop Seismic Data Compo	perties Type: Model onent: Compressional velo	▼ SGY	'Headers
Seismic File Mea	surement Unit	Trace statistics	
Z Axis:	Depth 🔻	N of traces	14577
Distance:	m 🔻	Samples per trace	815
Velocity:	m/s 🔻	Z step	5 m
Density:	kg/m^3 👻	Zmin 0 Zmax	4070 m
		Reset Coordinates	?
	ОК	Cancel Apply	Help

If you need to restore the trace parameters and coordinates, please delete the corresponding **<seismogram_file_name>.cr0** file.

You can change color representation for displaying seismic data. The package includes 10 standard palettes (blue-yellow-magenta, iridescent, black-white and etc.). You can create a custom palette by clicking on Edit button in Common tab. The minimal and the maximal values for the color palette may be specified manually or left for the program to calculate these values automatically (for each vertical section and for the whole dataset).
Seismic Properties	Seismic Properties
Common Units Layout Profile Zoom Rulers	Common Units Layout Profile Zoom Rulers
Location File Name: p\Haskell-Thompson test\Untitled+GathAP-Z.sgy Browse	Orientation of Coordinates
Seismic Viewer Model/Cube Seismogram VSP Seismogram Raw Traces	$ \begin{array}{c} \textcircled{\begin{tabular}{cccccccccccccccccccccccccccccccccccc$
Palette Seismic File(s) Show Edit. Min Value: -6512 Invert Amplitudes Calculate Max Value: 6512	Draw Features Draw Recievers
Show Show	Ingnight zeros grey Traced Ray Reflection Points Show points Show labels
OK Cancel Apply Help	Receivers' view modes OK Cancel Apply Help

In the Layout tab, it is possible to define the parameters for visualizing the acquisition system. In the drop-down list of <u>Seismic viewer</u> from the <u>Common</u> tab you may select the display mode for the acquisition system. These modes are described in more details below.

For different seismic files, the number of the receivers may vary from hundreds to millions, and therefore several ways of displaying these receivers are implemented, such as small black crosses, grey dots and contours.

Seismic Data Comp	Type: Seismogram onent: Vertical Particle Vel	▼ SGY	Headers
Seismic File Mea	surement Unit	Trace statistics	
Z Axis:	Time 👻	N of traces	100
Distance:	m 🔻	Samples per trace	1001
Velocity:	m/s 👻	Z step	2 ms
Density:	kg/m^3 v	Zmin 0 Zmax	2000 ms
		Reset Coordinates	?

The <u>Common</u> tab also allows adjusting the traces displayed in the vertical section. In the <u>Show</u> group, users can select whether the traces will be displayed as wiggle or image based on the user-defined palette. For multi-component seismic data, users can select the component to be displayed in the Seismic File Properties group from the Units tab.

In the Rulers tab, the parameters for displaying the Vertical and Horizontal rulers are specified. By default, both rulers are shown on the left and the right side of the object, but users have the option to either display the vertical scale on the left side, or just on the right side.

The profile parameters (vertical or horizontal section) can be defined in Profile tab.

13.9 2D Snapshot Viewer

To show the snapshots together with the shot gather, please choose the <u>Snapshot</u> View Window command under the View menu.



Please press the <u>Select Snap</u> button to select the file with a snapshot. Please press the <u>Select Shotgather</u> button to select the corresponding gathers. If the Model Frame is opened in the Tesseral Pro, the contours of the model will be shown in the snapshot. Navigation through snapshots and gathers is done with help of the corresponding sliders.

You can save the snapshots as a video by pressing <u>Capture</u> after which the <u>Animation Properties</u> window will appear.

Output Movie file:	's syntetic seismogram\snapshot.avi
~	
Scope	Lindow Program Window
Canon	
Options	
Frames pr	er second: 10
r ramos pr	
Compre	ession Microsoft Video 1

The movie will be saved in AVI format and the user must also specify the number of \underline{Frames} © 2019-2021

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per Second of video to be used from the Snapshot Viewer.

The user can specify the Compression Quality of the video by clicking Compression.

Compressor: OK Microsoft Video 1 ✓ Compression Quality: 85 ✓ ✓ ✓ ✓ About

Also, the <u>Temporal Quality Ratio</u> for the compressor can be subsequently specified by selecting Configure.

Configure			x				
Microsoft Video 1 Compressor Version 1.00							
Copyright (C) Mic Portions Copyr	rosoft Corp ight Media	o. 1990-19 Vision Inc	992				
Temporal Quality Ratio:		0.75	ОК				
•		Þ	Cancel				

Once all setting are specified, click <u>Okay</u> and the program will start recording the Tesseral Pro interface. Please note that closing the <u>Snapshot Viewer</u> window from this point on will interrupt the recording, and everything recorded so far will be saved as a video! If the user wants to record the <u>Snapshot Viewer</u> window only, it is recommended that you extend it to full screen and use the <u>Program Window</u> Scope in the <u>Animation Properties</u> window.



To stop recording press <u>Capture</u> and the video will be saved in the specified location, with the specified name in the <u>Movie file</u> dialogue.

13.10 3D Snapshot Viewer

In order to generate 3D snapshots please select check <u>Generate 3D snapshots</u> and select <u>Setup 3D Snapshots</u> in the <u>3D modelling Calculations Properties</u> window.

3D Modeling Calculation Properties	×
Computation Grid PropertiesSignal Frequency20HzCell (dx, dy, dz)10mautoTact (dt)0.47msautoMargin500mauto	Hardware Threads per process Max ▼ ■ Enable GPU (if CUDA available) GeForce GTX TITAN Black (4 G ▼ Required Memory (Host): 1.1 GB ? Required Memory (GPU): 2.2 GB
 Generate 2D snapshots Start Max Max Step Step Step Step Step Setup 3D Snapshots 	Generate Energy Field(s) Maximum Energy Maximum Divergence X Step: 10 m Y Step: 10 m Z Step: 10 m
	⊴ext > Finish Cancel Help

Which shap	shots to gen	erate and when	
For sho	t points:	0 ; All shot points	(can be several,
For mome	nts in time:	0.5	s E.g. "1 2 3")
Mesh steps			Generate Components
X step:	15	m	Stress
Y step:	15	m auto	Particle Velocity:
Z step:	15	m	🗌 X 🔲 Y 🔍 Z

The user then needs to specify the <u>Shot Points</u> and the <u>Component</u> for which snapshots need to be generated, as well as for which <u>Moments in Time</u>. The user can also adjust the default values for the <u>Mesh Step</u> for wave field propagations along the X, Y and Z axis.



As a result a SGY file will be generated for each specified shot point and its respective component, which will contain a snapshot image of the propagating wavefield at the specified time. In order to view the snapshot, the generated SGY file needs to be opened in <u>3D View</u> frame (<u>3D View>Add SEG-Y cube</u>). In order to achieve the best display, the user will need to adjust the visualization parameters in the <u>3D View>Selected object properties</u> window.

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Cube Properties	×
File name C: \Users\Stefan\Deskt	op\3D Elastic anisotropic method test
X-step 15 Y-step	15 Z-step 15
Palette	
Specify interval	Opacity 90 %
O Auto fitting by cube values	
Palette	
ОК	Cancel

Typically for an optimum visualization of the wavefield, a value 85%-95% for the <u>Opacity</u> works best. Also, reducing the <u>Magnitude within the Palette</u> will also enhance the display of the whole wavefield.

F	Palette	J
	Magnitude within -2 2 VEdit	
	Palette type Default Dipolar 💌	
1	Glow (%)	
l	100	
	Edit palette Discretization 9	
	2 .2 .1 .1 0 1 1 2 2	
	OK Cancel	

13.11 Prepare seismic files for loading

Sometimes, for unconventional gathers, some preliminary preparation is necessary before loading. Most often, the problems with loading SEG-Y files are caused by incorrect reading of the data related to the timing of the signal registration and incorrect reading of the data related to coordinates and altitude of sources and receivers. Partially, these problems can be solved in the <u>Seismic Properties</u> dialogue box (the <u>Seismic > Seismic Frame Properties</u> command).

Common	Units	Lavout	Profile	7000	Pulers				
omnorr	00	Layout	Frome	20011	Rulers				
Seism	ic File Pro	perties							
Sei	smic Data	Type:	Seismog	ram		-	C C C Y	Undere	
	Comp	onent:	Vertical	Particle V	elocity (Z)	• •	SGT	neaders	
Seismi	c File Mea	asuremen	t Unit		Tra	ce statisti	cs		
	Z Axis:	Time		-		1	N of traces	60	
	Distance:	m		-		Sample	es per trace	501	
	Velocity						Z step	2	ms
	velocity.	m/s			Zn	nin 0	Zmax	1000	ms
	Density:	kg/m^	3	-					
						Reset	Coordinates		?

In the <u>Seismic File Properties</u> dialogue box, please select the measurement units for scaling of the trace coordinates and of the trace interval. In this case, the content of the gathers itself will be not be changed. All changes will be saved in an auxiliary file named **<name of the gather file>.cr0**. If you press the <u>Apply</u> button in the <u>Seismic File Properties</u> dialogue box, the file with the suffix .cr0 will be deleted and the previously entered scaling constants will be cleared.

Sometimes, the trace coordinates in a SEG-Y file's header are located in non-standard cells.



To prepare a gather for loading, please choose the <u>Seismic > Raw Trace View</u> <u>Window</u> command. After the seismic file is chosen, 2 windows will be opened. In one of the windows, the trace preview is shown in the same order as the traces in the file, and in the second window, the table with headers of an individual trace is shown.



The key point for preparing a seismic file for loading is to select the headers' cells which correspond to the coordinates of the source and receiver. It is possible to allocate the coordinates of the source and the receiver to any cell in the headers by clicking the right mouse button in any cell of the header. This information (assign some header cells to the coordinates) will be saved in the file **<name of the gather file>.inf**, and, from now on, it will be used by the program.

Preview of all the trace headers enables to look through the trace headers as a set of values without name. You may specify the parameter offset to shift the starting point of displaying <u>the</u> headers.



The trace header may be displayed in two modes: Descriptive mode and Dump mode. In the Descriptive mode, only the headers with known names are listed. In the Dump mode, all headers are listed.

While looking through the header as a whole, the location of words is in the first column, the data type is in the 2^{nd} column and the values are shown in the third column. As different data types have different length of words, the lower part of the header is shifted automatically.

Tesseral Pro supports the following data types: CHAR (1 byte, -127~128), SHORT (2 bytes, -32767~32768), LONG (4 bytes, -2147483647~2147483648).

14 Map Frame

In Tesseral Pro, a model can be built from stratigraphic surface maps. The model is built automatically as a vertical slice cutting through the calculated (loaded) surfaces vertically along the selected line. More information about building models by using stratigraphic surfaces is described below. Firstly, let's describe the relevant capabilities for loading, calculating, displaying and processing surfaces.

14.1 Load surface from text file

Tesseral Pro supports loading surface from text files in various formats (the command $\underline{\texttt{File}} > \underline{\texttt{Load}} \\ \underline{\texttt{Surface}} \\ \underline{\texttt{File}}$). It is also possible to load grids in the following formats: XYV, isolines, separate points, Integral+, Surfer, Schlumberger, Triple, ZMap, Paradigm, GeoQuest, Landmark and Charisma.

The user can also generate surfaces on his own, by introducing in a text file the XYZ coordinates of the surface in 3 separate columns and then saving the file with an XYZ extension.

The survey the second to be	-	Carrier Second 1	-		and the second	straining through the last
Find						
Date and Incert						
time object 🛄 Select all						
nsert Editing						
3 • • • 2 • • • 1 • • • 🔏 • • • 1 • •	2 3 4	-57-	. 8 9 10	11 12 12 1	13 . 14 . 1	5 <u>人</u> 1・16・17・18・
517106	5045962	4750				
513974	5041486	5000				
511718	5041934	4750				
509364	5042402	4000				
506912	5042890	3750				
504362	5043396	4000				
502792	5043708	4000				
497790	5044702	3750				
497006	5044858	3500				
493278	5045599	2750				
488865	5046476	2500				
487099	5046827	2500				
483372	5047568	2750				
483078	5047626	3300				
479743	5048288	3750				
475329	5049166	4000				
472975	5049634	3750				
470916	5050043	3500				
466796	5050862	3000				
464933	5051232	1250				
						1

In the standard <u>File Open</u> dialogue box, please select the surface file and specify the proper format from the File type list for the selected surface file.

- Open				×
Look in:) 3D Model	•	(= 🗈 🖻	* Ⅲ▼
Recent Places	Name	ocal.grd		Date modified 11/27/2007 2:51 PM
Dedter	DELKPT(3)	-local.grd (4)-local.grd (1)-local.grd		11/27/2007 2:50 PM 11/27/2007 2:49 PM 11/27/2007 2:52 PM
Libraries Libraries Computer	File name:	Grid format XYV - CSV.TXT.DAT Isolines - CSV.TXT.DAT Separate points - CSV.TXT.DAT Grid format Integral- GRD Grid format Surfer GRD Grid format Surfer GRD Grid format ZMap TXT Grid format ZMap TXT Grid format GeoQuest TXT Grid format GeoQuest TXT Grid format Charisma-YX TXT Grid format Charisma-YX TXT All files		Qpen
	Files of type:	Grid format Surfer GRD	Discrete	values

You may select several files of the same type for a group loading.

Then, in the next dialogue box <u>Calculate Isolines</u>, please specify the parameters for calculating the isolines or click <u>Cancel</u>, if you do not want isolines to be shown on the surface.

Calculate Isolines
Calculate isolines with step 50
Size of working area
Width 129 Height 113
Magnitude of values
Lowest 2982.19873
Highest 3295.04257
OK Cancel

Please see the results



Please repeat this operation to load other surfaces.

Tesseral Pro saves all loaded surfaces as a general block in a Tesseral Pro document. Please use the <u>Map</u> Frame to display a surface. While deleting the <u>Map</u> Frame, the last showed surface in this Frame is not deleted and it will remain in the block of the calculated (loaded) surfaces in the Tesseral Pro document. You can show this surface in another <u>Map Frame</u> by selecting it from a list. Please use <u>Map > Manage/Delete Maps</u> to manage the surfaces loaded in Tesseral Pro. More detailed information can be found in the Section 14.2.5.

NOTE: The <u>Undo</u> and <u>Redo</u> commands do not apply to actions performed on surfaces (loading, calculating, processing, deleting), but they do work for the changes related to the <u>Map</u> Frame (selecting a surface for display, color adjustments, scaling, Frame re-size and etc).

14.2 Calculate surfaces using well data

To build surfaces by using the intersection of well layers, Tesseral Pro requires an existing MS Access or MS SQL Server database with well coordinates, altitudes and/or inclinometry and stratigraphic well depth values. More detailed information about how to load such information into the geophysical database can be found below in the Section 17.

14.2.1 Select fields for the project

As the database may include several independent fields, users need to select the "working" field before surface building, which can be done using the command $\underline{\texttt{File}} > \underline{\texttt{Project Properties}}$. Please also select the directions of the coordinate axis for the surface maps you want to build.



NOTE: Once Tesseral Pro is loaded, it is not yet connected to the database. Please use the Load Database button in the left part of the window to connect to DBMS MS SQL Server or to MS Access and to load the Tesseral Pro database. More information about connecting to the database can be found in the Section 17.4.

NOTE: It is also possible to select a field using the command <u>Select a field for</u> <u>the project</u> from the context menu by right-clicking the mouse on the field's name in the database tree.

14.2.2 Create Frame Map

Please use the command <u>Map > Create Map</u> (New Frame). Then, a map with the wells of the selected field will appear.



All commands for editing the map are located in the Map menu.

14.2.3 Working area

The working area (the area where the surface is built) is defined by an interval (m or ft) along the X and Y axis. The working area is defined in the <u>Map Properties</u> dialogue box of the Map Frame.

Map Properties	X		
Edit top title Size Edit bottom title Width 159 m Height 76 m Project Properties and Coordinate orientation Work area	m Font Palette m ☞ Background ☞ Ruler		
Layers Active Layer CCAT(2)_local.grd Show Grid (fill color) Draw Isoline Font height (%) 90	Isolines Properties Acquisition Geometry		
Well Title At collar	Draw Geometry Background Show picture Background Picture	Work Area X min 35 X max 3955	OK Cancel
Seismic plan view	OK Cancel	Y min 35 Y max 4515	

The working area can also be selected visually by the mouse in the following modes: <u>Map</u> \geq <u>Zoom</u> <u>Mode</u> or <u>Map</u> \geq <u>Move</u> <u>Mode</u>. In both modes the selection (displacement) of the area is done by left-clicking the mouse on the <u>Map</u> Frame (press-drag-release).

NOTE: If the area was selected incorrectly: (1) To cancel the last action, please use <u>Edit > Undo</u>; (2) To zoom the area, use the command <u>Map > Zoom Mode</u>, and then select the area again.

Please see the results



14.2.4 Surface mapping

Surface mapping is based on the intersection data of well layers. Tesseral Pro supports 8 mapping methods, such as the spline-approximation and Kriging.

To create new surface maps, please use the <u>Map > Calculation of Horizon</u> <u>from Well Tops</u> menu command. In the <u>Add new surfaces</u> dialogue box please select the layers, for which you want to build the surface maps.

	Add new surfaces				×
	Select strata				
	Layer name Cre	Wells	Top/Bottom	Strata name	^
Select layer(s)	AN1 : Bottom	5	Bottom	AN1	
from list	AN1: Top	5	Тор	AN1	
iioiii iist	AN2 : Bottom	5	Bottom	AN2	
	AN2 : Top	5	Тор	AN2	
	AN3 : Bottom	13	Bottom	AN3	
	AN3 : Top	13	Тор	AN3	
	AN4 : Bottom	8	Bottom	AN4	
		8	Top	ΔN/4	
		-	nop Dettern		-
Use the list to select	•				•
lavers automatically					
	Automatic select layers No		-	ОК	Cancel
	No				
	All				
	Only by all wells				
	Only exists				
	Only tops				
	Unselect				

Next, select one of the mapping methods available from the list.

Choose mapping method		×
Method Spline-approximation	•	OK
Analog (do not use)	•	Cancel

NOTE: Depending on the input data, the most suitable method is selected automatically from the list.

The surface calculation for the selected layers will be done automatically by the selected mapping method.

Please see the results



NOTE: If you want to re-build surfaces using another mapping method or to build other layer surfaces, please choose the command $\underline{Map} > Add New Horizon from Well$ <u>Tops</u> again. The program will propose you to delete the existing surface if you want to re-calculate it again.



14.2.5 Handling surfaces

Please use the command $\underline{Map} > \underline{Manage/Delete Maps}$ to delete and modify the properties (name, top and bottom) of any surface displayed in the \underline{Map} Frame.



NOTE: The <u>Undo/Redo</u> commands are not supported while handling surfaces (creating, loading, deleting).

14.2.6 Surface display

The display parameters for the <u>Map</u> Frame can be changed in the <u>Map</u> Properties dialogue box (the command <u>Edit > Edit</u> Frame Properties or <u>Map > Map</u> Frame Properties).

Map Properties	×
Edit top title Size Width 145	mm Palette
Surface selected from general list and displayed in the frame	mm Background
Active Layers	Work area Project Properties and Coordinate origination
Well Title At collar	Changing project parameters will delete all surfaces in document
Value Color Font height (%) 80 ÷	
Acquisition Geometry Background Display seismic Show picture	Map-substrate (picture)
plan in map Seismic plan view Image: Draw Seismic frames plan Image: Draw sources from seismic file	OK

NOTE: The <u>Map</u> Frame "does not contain" the loaded and calculated surfaces. All surfaces are saved into a common block in the Tesseral Pro document (<u>Map > Manage/Delete Maps</u>). The <u>Map</u> Frame is used to display any of the loaded (calculated) surfaces. It means that, in any <u>Map</u> Frame, you can show any surface from the common list. Deleting a surface from this list will lead to its "disappearing" from all <u>Map</u> Frames where this surface was shown. The commands <u>Map > Active Map</u> (rotation, displacement, and smoothing) can also change the surface data itself (not only its display in the Frame).

To change the palette of the surface, please select the <u>Map</u> Frame with the mouse and then use the command <u>Edit > Palette</u> or click the <u>Palette</u> button in the <u>Map</u> <u>Properties</u> dialogue box.

Palette			×
Magnitude with	nin 3251.5080	2727.5393	🗖 Edit
Palette type	From brown to	o dark blue	•
Glow (%)			<u> </u>
Edit palette	e	Discretization	9 ;
3200	3100 3000	<u>1 2900 28</u>	00
	RP : To	p:1	
Cancel			

The displayed amplitude of the surface cannot be changed (scaled down) in the <u>Palette</u> dialogue box. But it can be changed by using the command <u>Map > Active Map</u> > Properties.

Surface properties	×
Name PRECAMB(1)-local.grd	
Surface type top	
Value interval	
Min (depth) 3040.37800504 Max (depth) 3380.94418419	
Clipping	
Gain (%)	
OK Cancel	

Here, it is also possible to change the model's name and the surface type. To change the surface itself (not only its display), please use the commands <u>Scale</u>, <u>Smooth</u>, <u>Rotate</u> from the menu <u>Map > Active Map</u> and in this case the commands <u>Undo/Redo</u> are not applicable.

14.2.7 Build model from surfaces

Before building a model using surfaces, it is recommended to load or calculate these surfaces in Tesseral Pro. You do not need to have all surfaces ready before building the model. This process can be iterative, i.e., you can delete, add, re-calculate surfaces and re-build the existing model using the new surface data.

The steps to building a model from surfaces are as follows:

STEP 1. Select the wells for the section line (profile) – To select wells among those displayed in the <u>Map</u> Frame, please right-click the mouse button on the well you want to add to the profile. Then, in the context menu, select the command <u>Add Well to Profile</u>. The picture will not be changed after selecting the first well. Please repeat the process to add the other wells.

😾 Untitled - TesseralPro - • · × File Database Edit View Model Map Seismic 3D View Run Help ▶ ▷ ☞ 묘 | 끄 끄 | 控 🛠 💯 🖉 📴 🔡 📴 🖄 🔛 國 🔍 Q Q Q 🔍 💷 💽 💷 🖥 🍺 🗙 📐 🗨 🕁 🗈 🖾 🌩 🎉 🎾 🚣 🕉 H Project (Save to cre Hodel Ιv 55 Seismic files 🖃 👩 Database (TesseralP 🗄 🗁 General (m) γ ÷-- 🔁 10 🗄 🛅 11 (DT) 7150 7160 7170 🗄 🛅 13 (DT) 25 15 🗄 🗀 14 490 + 15 (DT) 🗄 🛅 16 (DT) • 27 🗄 💼 17 (DT) 🗄 💼 18 (DT) 34 37 🗄 🛅 2 (DT) 480 16 ٠ 18 ÷-- 🔁 20 9 ± 21 (DT) Wells selected ± 🛍 22 (DT) to the profile ⊕ - 🛅 23 (DT) 🗄 🛅 24 (DT) 470 - C 25 (DT) - 26 (DT) 🗄 🛅 27 (DT) • 17 23 ÷ 28 (DT) ÷-- 🔁 29 6460 10 24 ÷- 🗂 30 21 🛉 – 🧰 31 ÷- 🗂 32 7150 7160 7170 F Þ STEP 1: Create Velocity Model > || STEP 2: Acquisition Geometry > || STEP 3: Run modeling > Synthetic seismograms creating: Hide point: 84 x 6 mm 1 frames selected

Please see the results

To delete a well from the profile, please use the command <u>Delete Well from</u> <u>Profile</u> in the context menu or the <u>Map > Profile</u> menu. To clean the entire profile, use the command Map > Profile > Empty Profile.

STEP 2. Draw section line – Please select the mode $\underline{Map} > \underline{Section Mode}$. Then use the left mouse button to draw (press-drag-release) a section line.

Please see the results



STEP 3. Create a model – Please use the command $\underline{Map} > \underline{Transmit Horizons}$ to Model to launch the Wizard for creating a model. More detailed information can be found in the Section 3.1.3.

STEP 4. Support of thin layering – If you would like to fill the polygon's parameters by the well log data, you need to load these log curves to the wells in the model via the dialogue box <u>Polygon Properties</u> (the command <u>Model > Edit Polygon</u>, after you select the polygon).

In the <u>Polygon Properties</u> dialogue box that opens, please select the acoustic log for automatic parameter setting <u>From Log</u> for the polygons created by surfaces. The remaining parameters of the <u>Model</u> Frame can be set right now or later via the dialogue box <u>Model ></u> Model Frame Properties. More details can be found in the Section 3.1.

Model Properties		×
Top title	Palette	Horizontal scale
Bottom title Height (mm)	145 Font	Vertical scale
	□ Background Well dat	a
Show Wells	Depth interval	Borehole
14	Top 0 P	Right side
Add > 16		Log 🗌 Log
Delete < 23	Bottom 3102 m	Layers 🗖 Layers
Delete all <<	Scale 1 31653.1 💌	Scale Scale
J		ackground Background
Zoom map 🗌 Draw section manually	Select logs to be displayed on wells	ndividual well properties
7.14e+006 7.16e+006		
8	Azimuth 139.2 Compon	ent Compression Velocity 💌
	Scale 1 254544 💌	Base seismogram
460 223 60	X beg. 483289.0 m	Base picture
8 7.14e+006 7.16e+006	Ybeg. 7141619.0 m	OK Cancel

Please see the results



NOTE: Choosing the command $\underline{Map} > \underline{Transmit Horizons to model}$ again when the <u>Model</u> Frame already exists will cause the model to be automatically re-built (1) from the selected section and profile in the map or (2) from the existing maps of the layer surfaces in the document.

STEP 5. Adjust model – More details can be found in the Section 3.1.10.

NOTE: During the adjustment of the polygons' parameters that have been created automatically from the <u>Map</u> Frame, please use the <u>By default</u> button in the <u>Polygon</u> <u>Properties</u> dialogue box to memorize these parameters; they will be automatically filled next time you create polygons from the same layers.

15 3D View Frame

In Tesseral Pro, the <u>3D View</u> Frame is used for visualizing the spatial distribution of the data from a database, a project or from a user file. To rotate the data contained in this Frame, please use the toolbar buttons when this Frame is selected. The data are displayed in a cube. You can customize the scale of each edge of the cube by using <u>Object Properties</u>. Use the linear <u>Zoom</u> slider to zoom the display. For the axis, different scales may be adjusted (<u>Horizontal/Depth Scale</u>). To access object properties, please double-click on the object or use the command <u>3D View > Object Properties</u> (in the 2nd case, the object should have been selected in advance by the mouse). The data can be loaded into the cube using the <u>3D</u> <u>View</u> menu. All the data loaded to the cube are displayed together in a unified coordinate system. Let's describe the <u>3D View</u> Frame in more details.



15.1 Seismic Data Visualization

<u>The 3D View</u> frame allows displaying seismic data in the SEG-Y, SDS-PC and TGR formats. To load the cube, please use the command <u>3D View > Add Cube</u>. The <u>Add Cube</u> dialogue box will appear. Then, please load the target file. The receivers are shown as small blue crosses. Initially, the whole area is covered by the selected receivers. To select a rectangular part of the whole area, please draw the diagonal of the square you want to select while holding the left mouse button. Use the minimum/maximum depth parameter to limit the depth range of the cube. By default, the depth range is from the minimum to the maximum throughout the cube. After pressing <u>OK</u>, the <u>Cube Properties</u> dialogue box appears for users to specify the cube properties. The parameter step is the distance between the two neighboring nodes of the loaded grid along each of axis. This parameter can be increased to speed up drawing. The other parameters in this dialogue box are used to adjust the color palette. By default, the range of the palette is set from the minimum to maximum values obtained from the file. To set the range of the palette automatically for the displayed data, please select the <u>Auto fitting by cube</u> <u>values</u> option.



NOTE: Setting the "step" parameter too high decreases the drawing quality.

The procedure of loading profiles is practically the same as described above.

15.2 Surface Visualization

Surfaces are loaded from files in the same way. The command <u>3D View > Add Map</u> <u>> From Project</u> is for loading surfaces from a Tesseral Pro project. After clicking <u>OK</u> in the <u>Add Map From Project</u> dialogue box, the <u>Map Properties</u> dialogue box will appear for each loaded surface. The palette can be defined either from the active surface or from any other surface (check the <u>Filling by another surface</u> option). The interval of the palette can be set by the user (<u>Set own interval</u>) or by the minimum and maximum values in the surface (<u>Auto fitting by surface values</u>) or by the minimum and maximum values in all surfaces in the Frame (<u>Set general depth interval</u>). Check the option <u>Apply to all</u> to apply the palette settings to all available surfaces.

15.3 Visualization of inclinometry logs, well logs and layers

To load wells from the database, please use the menu command <u>3D View ></u> <u>Add/Remove Wells</u>, then in the <u>Wells</u> dialogue box define the list of wells you would like to see in the Frame. To set well properties, use the command <u>3D View > Well</u> <u>Properties</u>.



15.3.1 "General" tab - General well properties

A well can be shown in form of a line or a 3D pipeline with a given radius (the <u>Fictive</u> <u>Radius</u> parameter) by checking the <u>Pipeline View</u> option. If the <u>Number of slices</u> <u>to form a pipe</u> parameter is increased, the image quality will be improved, however, this can affect the program performance. The <u>Length of a straight pipe section</u> parameter is not for displaying the inclinometry data saved in the database, but for selecting the values from the database, provided that the distance along the well between the two neighboring values is bigger than the given value of this parameter. This parameter affects performance of the program in the same way as the parameter <u>Number of slices to form a pipe</u>. You can limit the well in depth by using the parameters <u>Min and Max after checking the Depth range</u> option. The parameters <u>Width of well-log display region</u> and <u>Stratum marker: fictive radius</u> are used to adjust the display of the corresponding well logs and layers and are described below.



15.3.2 Well logs visualization

To add a well log into the Frame, please use the <u>Well Properties</u> dialogue box, and then go to the <u>Logging</u> tab. The <u>Well-log</u> list contains the names of the curves to be displayed in the Frame. All the options to the right of the list are for adjusting the active curve. The curves are added to the list by using the <u>Select Curves</u> dialogue box. Initially, the list in the <u>Select Curves</u> dialogue box contains all available curves from the wells in the Frame (if the Frame does not have any wells, the dialogue box will contains the list of all curves in the database). To obtain the list of the curves for one specific well, please select the required well from the list. The curve will be displayed in the Frame on the left or on the right of the well. The width of each curve can be edited in the <u>Well Properties</u> dialogue box. A value of 0 means that the curve will not be smoothed and it will have the minimum possible width. The curves with higher width values will be smoothed. The other settings for the curves are similar to the ones described in Section 3.2.10. The width of the region for curve display can be adjusted in the "General" tab by setting the <u>Width of well-log display region</u> parameter.



15.3.3 Layer Visualization

You can display special marks at the intersections of wells with the tops of layers. To do this, go to the <u>Strata</u> tab in the <u>Well Properties</u> dialogue box. The list on the left of the dialogue box shows available layers. The layers in the list on the right will be displayed in the Frame as circles on the wells. You can define the circles' width in the <u>General</u> tab by setting the Stratum marker: fictive radius parameter.
16 Annex A: Measurement units

To select the measurement units, the command $\underline{\texttt{File}} > \texttt{Project}$ Properties is used.

	Project properties
Measurement units for the project	Measure units Distance m Velocity m/s Density kg/m^3
	Select Project Fields (to frames Map) [65535] General (m) [65535] Gorobcivskoje (ft) [65535] New Field
	Coordinate Orientation $c \uparrow^{Y} \qquad c \downarrow^{Y} \qquad c \checkmark^{Y} \qquad $
	If you change a system of coordinates or fields all surfaces will be removed from project

Different data types and different frame types handle the measurement units selected in the project properties in a different way. For example, the database does not depend on the project, and each oil field (and even well) may have their own measurement units for depths and logging data depending on initially loaded data. Each gather could have been created in metric or imperial system, but it should correctly loaded into Tesseral Pro. Every kind of data can be "adjusted" to the chosen measurement units by using the appropriate settings and commands in Tesseral Pro.

The following section describes how to convert various input data into the measurement units you need.

16.1 Model Frame

The <u>Velocity</u> and <u>Density</u> parameters determine the output units for velocity and density in the model polygons' properties. <u>Distance</u> represents the units for model's length/width, coordinate binding and acquisition geometry. If the measurement units are changed in the project, the <u>Distance</u> may be re-calculated. If parameters <u>Velocity</u> and <u>Density</u> are changed, the polygons' data display is also changed.



If the model is loaded from other formats ($\underline{File} > \underline{Load Model}$), for which the measurement units are unknown, users need to specify the measurement units (Metric or Imperial) in the dialogue box below.

¢	Change the Model Frame to Fit Import
	The New Model Region
	Tob : 0 tt
	Left : 0 ft Right : 1000 ft
	<u>B</u> ottom : 3100 ft
	Input Units: 🔿 Metric 🔘 Imperial
	OK Cancel the model region change and continie import

After that, the loaded model will be transformed into the project's measurement units (if the file's measurement unit differs from the project's one). Additionally, the Distance of the loaded model may be adjusted manually by the command $\underline{Model} > \underline{Scale}$. It is possible to select the scaling coefficient for the model, and transform the measurement units from ft to m or vice versa.



16.2 Seismic Frame

If the measurement units are changed in the project, only the display in the current project's Seismic Frame is updated: gathers' distance, velocity and density are shown in the chosen measurement units; however, the data files themselves are **not** modified.

For example, if you have selected ft as distance units for the project, the display of trace coordinates will change accordingly. For instance, if the <u>Distance</u> option in the project is set to *meters*, a SEG-Y file is displayed as follows:



If the Distance option is set to *feet*, the same SEG-Y file is displayed as follows:



When the displayed data is in seismic formats <u>TGR</u> or <u>SEG-Y</u>, and the data is velocity or density, then their values will be scaled in accordance with the selected measurement units.

Please select the component of the seismic file to be displayed by specifying the <u>Component parameter in the Seismic File Properties</u> dialogue box which is invoked by Seismic > Seismic Frame Properties.

Seismic Properties		X
Common Units	Layout Profile Zoom I	Rulers
Seismic File Prop	perties	
Seismic Data	Type: Seismogram	SGY Headers
Compo	Vertical Particle Ve	loaty (Z)
Seismic File Meas	surement Unit	Trace statistics
Z Axis:	Time 👻	N of traces 60
Distance:	m 🗸	Samples per trace 501
Velocity:	m/s 👻	Z step 2 ms
Density:	tg/m^3 👻	Zmin 0 Zmax 1000 ms
The measurement of data in the file	units	Reset Coordinates ?
	ОК	Cancel Apply Help

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16.3 Map Frame

If the project's measurement units are changed, the loaded and computed surfaces will be deleted. To transform the size of the loaded surface from m to ft or vice versa, use the command Map > Active Map > Scale Boundaries.

Scale su	face		×
Xmin	: Xmax:	Ymin:	Ymax:
From	rectangle		
35	3955	35	4515
to rec	tangle		
35	3955	35	4515
	Convert from ft l	om Co	powert from m to ft
	Convert nominit		
	C	OK)	Cancel

In the dialogue box above, please press <u>Convert from ft to m or Convert from m to ft</u> to convert the measurement units for the selected surface.

To convert the surfaces built by a database of well intersections, it is possible to change the distance measurement units in the database (oil field or well), and then build the surface again.

16.4 Database: transform the measurement units

Please see Section 17 for details about content and filling of the database.

The contents in the database do not depend on the selected measurement units in the project. Furthermore, some data in the database (for example, a particular field) may contain data in the imperial measurement system and other data may be in the metric one. To transform the data for such field from one measurement system to another, please select the field with mouse in the database tree, and then choose the command Database > Convert Units.

Convert units	x
Field: ALL	Well: ALL
Data to convert	Direction • meters to feet • feet to meters
l Logs	Convert Cancel

In the dialogue box above, select the data you would like to convert and conversion direction (from ft to m or from m to ft).

NOTE: Before well data is used for model building, the data must be converted to the project's measurement units (the command <u>Database > Convert</u> Units).

The values of curves loaded to the database may also be converted, but it has to be done one by one. To do this, please select the needed curve in the database tree, and choose the command Database > Data Properties.

Log Properties
Field General (m) Well 1
File Name 1.las Method DT
Description
Position
Start 200 Stop 3200 Step 0.2000000
Points 1550 Vmin 177.47500 Vmax 305.45800
Edit Log Manual Draw Smoothing Delete
Show Initial Log Carronsform
177.47 305.45
2892
2900
2904
2908
2912
2920
·····
Scaling
Scale = 566 OK Cancel

In the Log Properties dialogue box, check Edit Log and press Transform. In the next dialogue box Transforming Data enter the scaling coefficient.

Transforming Data	×
Multiply by: 1	Add: 0
Apply to	
C Interval	All log
	OK Cancel
L	

It is recommended to perform such data transformation for all the acoustic logs in all wells of the same deposits, so that the same measurement units are used.

After having normalized the logging data, it is possible to choose the measurement units for all curves of the model during model creation by well data, by specifying the <u>Measurement unit</u> parameter in the <u>Log</u> dialogue box.



While the polygon's parameters are filled with interpolated well data, the logging data are first converted to the selected measurement units of the project (m/s, ft/s, kg/m³, g/cm³). To ensure correct conversion of the measurement units, the measurement units for logging must be correctly set in the <u>Measurement unit</u> parameter.

17 Annex B: Geophysical database

To connect to the database, expand the upper node of the <u>Database</u> tree in the left pane of the Tesseral Pro window.

Untitled - TesseralPro				
<u>F</u> ile <u>D</u> atabase <u>E</u> dit <u>V</u> iew <u>M</u> odel M	<u>a</u> p	Seismic 3D View Run	<u>H</u> elp	
▶ 🗅 🛎 🖬 🖾 🕮 🛣 🕷	2	🗇 🚰 🏭 💵 🚈	। 📲 🔣 🖳 🗨 Q 🕀 🛙	00%
至264四回				
🗄 🖓 Project (Save to create workspace)			A	
- 🔁 Model				
Map				
+SS Seismic files				
±				
	Intitled - TesseralPro Eile Database Edit View Model M D	VINITIED - TesseralPro Eile Database Edit View Model Map D	VIntitled - TesseralPro Eile Database Edit View Model Map Seismic 3D View Run D	Untitled - TesseralPro Eile Database Edit View Model Map Seismic 3D View Run Help D D

17.1 DBMS

Tesseral Pro uses DBMS MS SQL Server or MS Access to store well log data.

17.2 Diagram of Classes



17.3 Description of tables and basic fields

Tesseral Pro has the following well log data structure:

The upper level is Fields (<u>Fields</u> table). The database can contain several fields. The fields contain wells (<u>Wells</u> table). Each well may only belong to a single field.

A well can contain:

• Stratigraphy (<u>Strata</u> table) with stratigraphic well cuttoffs.

• Well inclinometry (Inclinometry table).

Well logs (Logs table)



 $\frac{\texttt{Fields}}{\texttt{(name of the fields)}}$. The main attribute is <u>Name</u>

Field Properties		×
Name General (n)	
	OK	Cancel

<u>Wells</u>: Belongs to a field. The main attributes are:

• Number – Well number (name)

• x, y – Well coordinates

 <u>EBK</u> – Elevation Kelly Bush (corresponds to the <u>Elevation Kelly Bush</u> parameter in the <u>Well Properties</u> dialogue box)
 <u>Borehole</u> – Well bottom (corresponds to the <u>Bottom</u> parameter in the <u>Well</u> <u>Properties</u> dialogue box)

Well Properties		
Field General (m)		
Number 1	Elevation Kelly Bush (EKB)	85.6
x 490454.81	Bottom	0
У 7172923.5		
	ОК	Cancel

<u>Inclinometry</u>: Belongs to the well. It contains the table with coordinates of the marks along the borehole.

• $\underline{\text{Depth}}$ – Depth mark from the wellhead

• $\underline{x}, \underline{y}$ – Borehole deviation from the wellhead at the current depth mark

• \underline{z} – Absolute depth of the current well mark from the sea level; positive values mean 'below the sea level', negative otherwise

Inclinometry			
depth	x	у	z
0	0	0	-85.6
20	0	0	-65.6
40	0	0	-45.6
60	0	0	-25.6
80	0	0	-5.6
100	0	0	14.4
120	0	0	34.4
140	0	0	54.4
160	0	0	74.4
180	0	0	94.4
200	0	0	114.4
220	0	0	134.4
240	0	0	154.4
260	0	0	174.4
280	0	0	194.4
300	0	0	214.4
320	0	0	234.4
340	0	0	254.4
360	0	0	274.4
380	0	0	294.4
400	0	0	314.4
420	0	0	334.4
440	0	0	354.4
460	0	0	374.4
480	0	0	394.4
500	0	0	414.4
•			•
			Close

Strata: Belongs to the well. It contains the table of the well's layer-intersections. The main attributes are:

• <u>Well strata</u> is the name of layers

• \underline{Type} defines the stratigraphic type (layer/mass/suite/stage and etc) of the current layer. The table of allowed database's stratigraphic types is <u>strata</u> type

• <u>Strata code</u> is the layer code in the database's code table <u>strata code</u>. It is used for automatic building of surfaces by using the layer-intersections

- <u>Depth</u> is the depth of layer intersection
- $\underline{x}, \underline{y}, \underline{z}$ are the absolute coordinates of the layer intersection
- <u>Is Bottom</u> '1' for bottom, '0' for top

Field strata	Well strata	Depth	Туре	Is Bottom	x	у	z
14 (Atlimskaya)	Atlimskaya	354.1	stratum	0	490454.8	7172923.5	268.5
14 (Atlimskaya)	Atlimskaya	393.0	stratum	1	490454.8	7172923.5	307.4
15 (Tavdinskaya)	Tavdinskaya	395.1	stratum	0	490454.8	7172923.5	309.5
15 (Tavdinskaya)	Tavdinskaya	454.3	stratum	1	490454.8	7172923.5	368.7
16 (Lulinvorskaya)	Lulinvorskaya	456.9	stratum	0	490454.8	7172923.5	371.3
16 (Lulinvorskaya)	Lulinvorskaya	684.8	stratum	1	490454.8	7172923.5	599.2
17 (Taliskaya)	Taliskaya	689.8	stratum	0	490454.8	7172923.5	604.2
17 (Taliskaya)	Taliskaya	855.0	stratum	1	490454.8	7172923.5	769.4
18 (Gankinskaya)	Gankinskaya	859.4	stratum	0	490454.8	7172923.5	773.8
18 (Gankinskava)	Gankinskava	1102.6	stratum	1	490454.8	7172923.5	1017.0

Strata Code: Belongs to the layers (stratigraphy). It contains the table with the codes of field layers.

The main attributes are:

- <u>Number</u> is the layer code in the database's code table <u>strata</u> code
- <u>Name</u> is the name of the layer code

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<u>n.of</u> wells is the number of wells, where a layer with the specific code is

used



Strata type: Belongs to the layers (stratigraphy). It contains the table of layer types.

The main attributes are:

• <u>stratum type</u> is the layer's code in the layers codes table of the database strata code:

 $\underline{\text{Logs}}$ (log curves): Belongs to the well. It contains the table of the well logs.

The main attributes are:

• Method is the layer's name

• \underline{Start} , \underline{Stop} are the curve's top and bottom

• <u>Step</u> is the curve's sampling step

• <u>Vmin</u>, <u>Vmax</u> are the curve's amplitude range



17.4 Database connection, creation and copying

Connection to the database is established automatically while loading Tesseral Pro or by using the command Database > Connect.

Conn	ect to database					×
c	SQL Server — Provider: Server: Database:	SQL Server 2005 Express (local)	Ĩ	MS Access File Name C:\Tesse	: (*.MDB) : ral Technologies\Tesseral Proʻ	Browse
c	- Custom Connec	tion String soft.Jet.OLEDB.4.0;Data Source=C:\Tess	blogies\Tess	seral Pro∖TesseralPro.mdb;Jet 0	LEDB:Syst	
			- Auther Login	ntication —		
			Passv	vord:		
			Defa	alt	Connect	Cancel

Please select the DBMS you would like to connect to, and adjust the connection parameters. The MS Access test database TesseralPro.mdb with several wells is included in the installation.

To back up the Database, please use the command <u>Database > Backup</u>. For MS Access:

It creates a copy of the ".mdb" file by using the standard <u>Save As</u> dialogue box. For MS SQL Server:

Backup Database	×					
Database Name: TesseralPro						
_ Data Properties						
Backup to:						
ram Files\Tesseral Pro\TesseralPro.bak Browse						
This path is local to SQL Server. If you are using Tesseral Pro and Microsoft SQL Server on different computers, please use the path on SQL Server computer. This is why Browse button is disabled.						
Cancel Backup						

Please provide the full path and name for the backup copy. It is recommended to back up the database before operations that could lead to data loss like loading and deletion, so that, in case of any incorrect actions, the database can be recovered from the backup copy.

To create or restore a Database, please use the command $\underline{\texttt{Database}} > \texttt{Create}/\texttt{Restore}.$

MS Access creates a new ".mdb" file while creating a new database by using the standard Save As dialogue box. Restoring such Database is not supported, so please use the command

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<u>Database > Connect to connect to another ".mdb" database</u>.

When MS SQL Server creates a new database, please enter the <u>Database Name</u>, and then select <u>Create Empty Tesseral Pro Database</u>. To restore a database from the backup copy, please select <u>Restore Backup</u>, and then define the full file path and the name of the backup created previously.

Create/Restore Database
Database Name: TesseralPro
Data Properties
C Create Empty Tesseral Pro Database
Collation Cyrillic_General_CI_AS
Restore Backup
C:\Program Files\Tesseral Pro\TesseralF Browse
This path is local to SQL Server. If you are using Tesseral Pro and Microsoft SQL Server on different computers, please use the path on SQL Server computer. This is why Browse button is disabled.
Cancel

NOTE: All current data will be lost while restoring the database from a backup copy

17.5 Data loading

The data is loaded into Tesseral Pro either from LAS files (to the <u>Logs</u> table) or from text files to the tables <u>Wells</u>, <u>Inclinometry</u>, <u>Strata</u> and <u>Strata</u> code. Data can either be loaded to an existing well, or loaded to a field, in which case the program "distributes" the data from the file over the existing wells or creates new wells automatically.

Data in text files (TXT, CSV, and TAB) must be presented in the form of columns (the columns are separated by spaces, tabs or semicolons). It is preferable that each column has its own header. For example,

Well Number	X	V	ekb	borehole
1	490454.8	7172923.5	85.6	3502
2	482493.0	7160560.5	96.4	3812
5	484796.1	7155446.5	89.7	3555
6	475956.6	7158533.5	100.0	3456
7	472471.0	7156297.5	100.4	2544
8	476867.3	7163649.5	91	3514
9	477733.9	7156292.5	98.2	3098
10	459056.6	7146075.5	92	3113
11	496123.6	717966674.9	11	3221
12	498422.6	718709668.9	12	2801
13	480333.9	7165486.5	87.7	4121
14	470601.8	7153447.5	105.6	3434

The first column is the obligatory well number where the data is to be loaded. To prepare data for loading, please use the command <u>Database > Prepare Text Tables</u>. To load prepared text files or files in LAS format, please use the command <u>Database > Import</u> Data.

STEP 1. Create a field – Please use the command <u>Database > Add Field</u>, and then set the name of the new field in the pop-up dialogue box

STEP 2. Load well coordinates, elevations and well bottoms – Please use the mouse button to select the field into which you would like to load the data, and then choose the command Database > Prepare Text Tables

🛃 Text Table Lo	ader						×
File Edit Tab	le						
Data to import:	wells	▼ Field	: General (n	1)	▼ Well:	<any></any>	v
							<u> </u>
							=
-							_
							_
-							
-							
-							
							r
						Import	Cancel

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In the Data to import list, please select wells.

If you have a text table with the necessary information, please use the command $\underline{\texttt{File}} \geq \underline{\texttt{Open}}$ in the $\underline{\texttt{Text}}$ $\underline{\texttt{Table}}$ $\underline{\texttt{Loader}}$ dialogue box. If the data are in Microsoft Excel or Word format, use the $\underline{\texttt{Copy/Paste}}$ commands to transfer the data from the MS Office document to $\underline{\texttt{Text}}$ $\underline{\texttt{Table}}$ $\underline{\texttt{Loader}}$ via the Clipboard.

	File	ext Table Loa Edit Tabl	Table whe is to be loa	re the data aded	Field	to load	×
	Data	a to import:	wells	▼ Field:	General (m)	•	Well: Anv> Database attribute names
		Mall Number			alda	harshala	
		Well	X	Y	EKB	Bottom	Header from the file
		6	2580	3180	99.4	4111	being loaded. It can
		8	6090	3210	101.5	5230	contain any text
		9	3270	5830	94.2	4832	
		10	3890	3070	99.1	4600	
		11	3620	3660	100.1	4768	
		12	4510	4690	91.8	4996	
Colum be fille	n with [.] d	well numbe	r. Must	Co	lumns with d	ata	
	-					_	
							Import Cancel

The first column from the text table is obligatory and contains the number of wells into which the data is to be loaded. The light green (second) row is optional and it is intended for the headers from the input file. In the first yellow row, all the attribute names of the columns you want to load should be entered. Click the mouse inside each of the cells to select the attribute, into which the data from the column are to be loaded.

It is not necessary to load coordinates, bottom of the hole, and altitude all in one table; sequential data loading (amending) to the wells from several files is supported.

Please use the command $\underline{File} > \underline{Save} as \underline{text}$ in the $\underline{Text} \underline{Table} \underline{Loader}$ dialogue box to save the prepared table as a text file.

NOTE: There is no <u>Undo/Redo</u> command in the <u>Text</u> Table Loader dialogue box. Therefore, it is recommended to save partial results periodically by using the <u>File</u> > Save command.

When the table is ready, please press Import to load the data into the selected field.

After data has been imported, it is recommended to QC the result; use the mouse to select any loaded well and then choose the command <u>Database > Data Properties</u>.

Well Prope	rties		×
Field G	eneral (m)		•
Number x	1 490454.81	Elevation Kelly Bush (EKB) Bottom	85.6
У	7172923.5	ОК	Cancel

In the <u>Well Properties</u> dialogue box, you can modify any data and save them to the database using the OK button.

STEP 3. Load inclinometry. Generally, loading inclinometry is similar to loading well coordinates. Please select a field where you would like to load the inclinometry data by the command Database > Prepare Text Table, and then select inclinometry from the Data to import list.

ata to import:	inclinometry	▼ Field:	General (m)		▼ Well: <a< th=""><th>lny></th><th>•</th></a<>	lny>	•
	,		, ,				
Well Number	denth	Y	v	7	zenith angle	azimuth	
WellNumber	Depth	x	у Ү	Z	zonian_anglo	GEIMOLT	
1	0	0	0	-85.6			_
1	20	0	0	-65.6			
1	40	0	0	-45.6			
1	60	0	0	-25.6			
1	80	0	0	-5.6			
1	100	0	0	14.4			
1	120	0	0	34.4			
1	140	0	0	54.4			
1	160	0	0	74.4			
1	180	0	0	94.4			
1	200	0	0	114.4			
1	220	0	0	134.4			
1	240	0	0	154.4			
4							

To use the inclinometry data in Tesseral Pro, the columns <u>depth</u>, <u>x</u>, <u>y</u>, <u>z</u> need to be filled. The remaining columns are only informative and they do not influence the borehole shape.

Apart from the first column (well number), the order of the other columns is not important. The rows order for a single well is also not important, but it is not recommended to have the data in the file related to the same well shaped like "blocks"; it is better to sort all wells by well number.

Once the table is ready, please press Import to load the data into the selected field.

After loading, it is recommended to check the loading result. For this purpose, please select the <u>Inclinometry</u> branch for any of the loaded wells, and then choose the command Database > Data Properties.

Inclinometry				x
depth	x	у	Z	•
0	0	0	-85.6	
20	0	0	-65.6	
40	0	0	-45.6	
60	0	0	-25.6	
80	0	0	-5.6	
100	0	0	14.4	
120	0	0	34.4	
140	0	0	54.4	
160	0	0	74.4	Ŧ
<			- F	
			Close	

For correct mapping, the table <u>Inclinometry</u> must be filled (for the wells you want to use for mapping). If you have no inclinometry data, the wells can be assumed to be vertical, and © 2019-2021

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then the inclinometry data can be generated automatically; this can be done by the command Database > Create Inclinometry.

Create vertical inclinometry		×
Field:	Select wells:	*
Select wells without inclinometry	10 11 12 13	E
Select wells with altitude and bottom	13 14 15 16	
Create inclinometry	10 17 18	
Done	20	-

In this dialogue box, please select the wells for inclinometry generation from the list on the right, and then press <u>Create inclinometry</u>. For automatic creation of inclinometry, the information about the well's altitude and bottom hole is used from the <u>wells</u> table. While creating inclinometry in the absence of this data, you will be prompted to enter the altitude and bottom of the hole manually in a dialogue box.

Use the buttons <u>Select wells without inclinometry</u> and <u>Select wells</u> with altitude and bottom for automatically selecting the wells in the list.

The result of executing <u>Create</u> inclinometry is shown below for a well.

Inclinometry			×
depth	x	у	z
0 3280	0	0 0	-68.9 3211.1
•			•
		[Close

NOTE: In case that the selected well already had inclinometry data, the old data will be deleted.

NOTE: If you do not like the results of loaded inclinometry, please select the field with the mouse and then use the command <u>Database > Delete from Field ></u> Inclinometry and repeat loading again.

STEP 4. Load stratigraphy. Generally, loading stratigraphy is similar to loading well coordinates and well inclinometry. Please select the field you want to load the stratigraphic layouts with the mouse and then choose the command <u>Database > Prepare Text Tables</u>. Please select <u>strata</u> from the <u>Data to import</u> list.

igend File Edit ™	Loader Fable						×
Data to impo	rt: strata	3	▼ Field:	General (m)	•	Well: <any></any>	•
							A
Well Numb	ber is	Bottom	depth	name			
WellNumb	ber Isł	Bottom	Depth	Name			=
	6	1	140	KZ			
	6	1	225	ĸ			
	6	1	685	J			
	6	1	1232	T1(dr)			
	6	1	1620	C2m			
	6	1	2240	C2b			
	6	1	2392	C1s2			
	6	1	3255	C1s1			
	6	1	3950	C1v2			
	6	1	4111	D3fr			
	6	1	3950	D3			
	7	1	135	KZ			
	7	1	283	K			-
C.	7		770				•
			111				,
						Import	Cancel

The main attributes are <u>name</u> (layer name), <u>depth</u> (layer-intersection depth along the borehole), <u>isBottom</u> (1-bottom, 0-top). If the absolute coordinates of the layer-intersection are available, it is worth loading them into the database. Otherwise these coordinates will be calculated automatically every time before calculating a layer surface map.

Apart from the first column (well number), the order of the other columns is not important. It is recommended to sort the rows in advance by well numbers.

Once the table is ready, please click <u>Import</u> to load the data into the selected field.

During the loading process, if a layer name is not found in the <u>strata_code</u> table, you will be prompted to assign/create a layer code for this layer in the dialogue box below.

Assign a va	alue	x
New stra existing s	ta name found! You can create new strata or assign it to strata. Strata name is: KZ	
K J C2m C2b C1s2 C1s1 C1v2 D3		•
Create	y to all new e new Assign Assign Empty Canc	:el

<u>Create</u> New is for inserting a new row into the database's layer code table. The new layer code in the well is assigned to this row.

Assign is to assign the layer code in the well selected from the list.

Assign Empty is for setting the layer code in the well to "0".

Cancel for no action

NOTE: The layer code is of great importance for surface-layer building by layerintersection data and automatic creation of polygons in the model. The attribute <u>name</u> is ignored in both cases and only the <u>strata_code</u> is used. Thus, it is recommended, whenever possible, to identify the new layer name with an existing code from the <u>Assign a value</u> dialogue box.

It is recommended to check the results of the loaded Stratigraphy by selecting the \underline{Strata} branch of any loaded well and then choose the command $\underline{Database} > \underline{Data}$ Properties.

Field strata	Well strata	Depth	Туре	Is Bottom	x	У	z
1 (KZ)	KZ	426.5	stratum	1	0.0	0.0	0.0
2 (K)	к	820.2	stratum	1	0.0	0.0	0.0
3 (J)	J	2329.4	stratum	1	0.0	0.0	0.0
4 (T1(dr))	T1(dr)	4068.2	stratum	1	0.0	0.0	0.0
5 (C2m)	C2m	5124.7	stratum	1	0.0	0.0	0.0
6 (C2b)	C2b	7299.9	stratum	1	0.0	0.0	0.0
7 (C1s2)	C1s2	8021.7	stratum	1	0.0	0.0	0.0
8 (C1s1)	C1s1	10465.9	stratum	1	0.0	0.0	0.0
9 (C1v2)	C1v2	14042.0	stratum	1	0.0	0.0	0.0
12 (C1(v1+t))	C1(v1+t)	14977.0	stratum	1	0.0	0.0	0.0

NOTE: If you do not like the results of the loaded stratigraphy, please select the field with the mouse and then use the command <u>Database > Delete from Field ></u> Strata and repeat the loading process again.

STEP 5. Load well log data – The well logging curves are loaded from LAS files for a well or a field with the command <u>Database > Import data</u>. A selection of multi LAS files is supported in the dialogue box. After having selected the file(s) and clicking the <u>Open</u> button, a dialogue box will appear for loading the curves into the well.

Import Logs	x								
File: C:\Sheldon\TestingOf	TesseralPro\SonicOnly.las								
IZIDT	Static	1							
GR	Start: 360 Step: 0.2000000								
	Stop: 2303 Count: 9714								
Import Skip Cancel									

Please click Import to load the selected curves into the database.

For QC of the loaded result, please select a curve from the <u>Logs</u> branch of the well, and then choose the command <u>Database</u> > <u>Data</u> Properties.

🔳 Log Pro	operties				×
Field Well	General (n 11	1)			
File Name	11.las			Method	DT
Descriptio	n				
- Position	ı ———				
Start	2873.1999	Stop	3325.1999	Step	0.2000000
Points	2118	Vmin	127.74800	Vmax	362.18798
🗌 Edit Lo	n da	Ianual Drav	/ Smoo	thing	Delete
	▼ s	how Initial I	Log Trans	sform	Select All
12	7.74				362.18
2904			خے		_
2908					
2912		-	<u></u>		
2916			Z		
2920			5		
2924			E		
2928			~		
2932			F		
2936		-	<u> </u>		
2940			۲_		
Scaling					•
Scale = 5	66		OK		Cancel

17.6 Data editing

A partial editing of the data loaded from LAS or text files for fields and wells can be done by using the dialogue box (<u>Database > Data Properties</u>).

Field strata	Well strata	Depth	Туре	Is Bottom	x	у	z
1 (KZ)	KZ	426.5	stratum	1	0.0	0.0	0.0
2 (K)	к	820.2	stratum	1	0.0	0.0	0.0
3 (J)	J	2329.4	stratum	1	0.0	0.0	0.0
4 (T1(dr))	T1(dr)	4068.2	stratum	1	0.0	0.0	0.0
5 (C2m)	C2m	5124.7	stratum	1	0.0	0.0	0.0
5 (C2b)	C2b	7299.9	stratum	1	0.0	0.0	0.0
7 (C1s2)	C1s2	8021.7	stratum	1	0.0	0.0	0.0
B (C1s1)	C1s1	10465.9	stratum	1	0.0	0.0	0.0
9 (C1v2)	C1v2	14042.0	stratum	1	0.0	0.0	0.0
12 (C1(v1+t))	C1(v1+t)	14977.0	stratum	1	0.0	0.0	0.0

In the <u>Well Strata List</u> dialogue box, the layer codes in the database can be inserted, deleted or modified by using the Field Strata button.

💽 Strata Code		X
Number	Name	n.of wells
1	KZ	5
2	к	6
3	J	6
4	T1(dr)	6
5	C2m	6
6	C2b	6
7	C1s2	6
8	C1s1	6
9	C1v2	6
10	D3	3
11	D3fr	3
12	C1(v1+t)	5
13	D3fm	4
14	Atlimskaya	20
15	Tavdinskaya	22
16	Lulinvorskava	48 *
Add		ОК
Delete		Cancel

NOTE: To change the layer code name, please double click on-its current name and then change the name in the edit field.

To edit the log curve, choose the command $\underline{Database} > \underline{Data}$ Properties and select the curve name from the database tree.



In the <u>Log Properties</u> dialogue box, please check <u>Edit Log</u> checkbox to enter the log editing mode. Then select the log interval by the mouse (press-drag-release), or use the button <u>Select All</u> to select the entire log. The selected log interval can be smoothed by using the <u>Smoothing</u> button or scaled by using the <u>Transform</u> button, or deleted by using the <u>Delete</u> button. A log interval can be drawn manually by using the mouse (press-drag-release) while the <u>Manual Draw</u> checkbox is checked.



18 Annex C: Licensing policy

Tesseral Technologies Inc provides several ways to license Tesseral Pro. For detailed information about license policy, please contact <u>tesseral@shaw.ca</u>

18.1 Single-user License

A *local alpha-digital key* is bundled to a particular computer. Licensing with the alphadigital key does not allow using this key in any other computers. This may be the most suitable choice for the package's trial license, a public standalone PC or permanent user-independent workplaces like a computer class at a training facility.

A *local hardware key (HASP)* provides the licensing when the HASP is plugged into a USB port of a computer. User can install the same Tesseral product on other workstations and use the same key. So this type of licensing is the most suitable for occasionally using Tesseral package on multiple work-places, e.g. both at home and in the office.

18.2 Network License

A network license is unique for the client's network. The license key is usually installed on one of the network PCs called a Server. It may be the best choice for bigger or scattered companies. Due to the increasingly toughening policies in Windows system administration, it may require some additional network administrating efforts (eliminating possible interference with particular network security features and local network Firewall settings) to support such configuration, but this type of licensing allows multiple users to utilize the common license directly from multiple network PCs, but a program must be initially installed on each of computers where Tesseral is running.

• A network alpha-digital key license is unique for the client's network. The license key is installed on one of the PCs from the network (a Server PC); it may be a virtual machine because this type of licensing does not require special hardware.

• A network hardware (HASP) key provides licensing when HASP is plugged into a USB port of any computer in the local network or VPN (Virtual Personal Network) to which the user's computer is connected.

18.3 Mixed Licenses

Any combination of the types of keys mentioned above can be used by the client for licensing Tesseral products. For example, a network HASP key for 3 workplaces, 2 local USB HASP keys and 2 alpha-digital keys can be purchased and used together as a license for 3+2+2=6 workplaces. Each type of key may be accompanied with a particular variant of the Tesseral product.

Licensing for evaluation period is usually done with local alpha-digital key.

18.4 Setting up a license

Licensing with Hardware key (HASP) allows users to run the Tesseral package by plugging an electronic USB device (called the HASP key – "Hardware Against Software Piracy") supplied by Tesseral Technologies Inc into a computer's USB port. The HASP key (Guardant) driver is Microsoft-certified.

A HASP key is initially coded for the latest version of a particular Tesseral product and configuration and might not work with future versions released as the package is developed. Upon the user request and payment for upgrade, this key can be coded for the upgraded version and product configuration via e-mail (users will receive necessary instructions in this case).

HASP key can be coded for un-limited period (permanent) or limited period (trial or leasing period), and, after this period, the package will not work until user gets a new permanent HASP key from Tesseral Technologies Inc or a code from Tesseral Technologies Inc via e-mail.

A HASP key is not bundled with a particular Tesseral installation CD.

The user must keep the HASP key and not lose it, because the company does not provide replacement of the HASP key, because it is impossible to verify the number of licenses actually used in this case. If a HASP key is damaged, users must inform company's Customer Service by e-mail and then send it via mail to the provided address to get a replacement key for its market price (about US\$ 50 for shipping and handling).

The green indicator on the USB device means that the drivers are correctly installed.

IMPORTANT NOTE!

ing Code

Incoming Key:

Insert Key

receive.

Regist

20

Please email this outgoing code to the Customer Service, and then enter the incoming key you

Please, visit http://www.tesseral-geo.com for information of how to obtain trial evaluation key.

W2H9KT71MX4M497MUSXNHAX6C6

(3)

🚔 Register Tesseral Pro

Alpha-digital key

(1)

HASP key

(2)

The new (2008) HASP drivers are strictly linked to the Windows' (not computer's!) bit number (32 or 64 bit). During the installation, the program recognizes the Windows type and installs the corresponding drivers. Insert the USB key only after the installation has finished. You can't mix 32-bit with 64-bit drivers if you have to install them manually.

The first time you run Tesseral Pro, the Registration Dialogue (see figure below) request users to specify corresponding license information.

Cancel

Connect

Depending on the license type, you have several options:

(1) Enter the alpha-digital key and press "Register"

(2) Insert the USB key and press "Insert Key"

(3) Enter the address of a Network Key Server and press "Connect"

18.5 Installing Guardant Network Services

To use network USB keys, it is required to install the Guardant Network Services on your computer that will serve as the key server. If you are not using network license, you may skip this section.

The Guardant Network Services can be downloaded for free by following this link: http://www.geopoisk.com/tesseral/download/GuardnetNetServices.zip

Detailed guide for installing Guardant Network Services can be downloaded by following this next link:

http://www.tesseral-geo.com/documentation/en/license/

TesseralNetworkLicenseInstallation.pdf

More technical details are described in the key vendor's manual: <u>http://www.tesseral-geo.com/documentation/en/license/Guardant_LAN_Guide.pdf</u> Unzip and run the installation program:



STEP 1. Click Next >



STEP 2. Select the Destination Folder and press Next >



STEP 3. Insert your USB key and then press Next >

🔂 Guardant-Net Services Sel	tup		
	Please, insert Guardant Network key now		
Editor 1			Please, press
0		the Ne	xt button after
1 1. 27-1.		you ins	sert your key
THE		/	
	< <u>B</u> ack <u>Next</u> >	Cancel	

a) You may run "Network key monitor" to check if your key is working properly

		Set Program Access and Defaults Windows Update						
al		Programs	,	١.	Accessories	•		
sion	\bigcirc	Documents	•		Guardant-Net Services Startup	•	1	Network key monitor Network key service
rofes		Settings	•		Internet Explorer Outlook Express	-	15	Uninstall
B	R)	Search	•					
S 200	4	Help						
Ę	2	Run						
ž		Shut Down						
	Start	🛛 🙆 🈂 🔰 🗌 🔂 Guardant N	et S	ervic	es			

b) ... and check: The "Host name"



STEP 4. To use the Remote USB key, please enter the "Host name" in the Tesseral registration dialogue box and press "Connect"

Alpha-d	igital key	
	Outgoing Code:	
		Please email this outgoing code to the Customer Service, and then enter the incoming key you receive.
	Incoming Key:	W2H9KT71MX4M497MUSXNHAX6C6
		Please, visit http://www.tesseral-geo.com for information of how to obtain trial evaluation key.
		Register Cancel
HASP	key	Network HASP key
	Insert Keu	Network Address:
		Connect

18.6 Troubleshooting

Read this part only when you encounter problems

1. Technical information for system administrators

• Guardant Network Services use the following TCP/IP ports (both ingoing and outgoing):

- 3182/TCP
- 3183/UDP
- 3184/UDP

For

- Configuration files for advanced settings:
- For

(in Guardant Net Services directory)

liant

NNKSRV32.INI

client:

server:

GNCLIENT.INI

(In Tesseral Directory)

2. Setting up the Firewall for system administrators



My d	😼 Control Panel									_ 🗆 🗙
	File Edit View Favorites	Tools Hel)							
Burn CDs & O	🕒 Back 🔻 🕤 🔻 🤣 🔎 Sean	ch 🜔 Folders								
DVDs	Address 🔂 Control Panel									💌 🔁 Go
2	Control Panel *	AC3 Filter	Ġ.	Ń	ø	-	2	ASE	and the second s	P
avast! We Antivirus k	Switch to Category	AC3 Filter	Accessibility Options	Add Hardware	Add or Remov	Administr Tools	Automatic Updates	Broadcom ASF Con	Broadcom Control	Date and Time
	View	<u>s</u>	N.	\square	a contraction of the second se	and the second se		格	Providence	٢
WORD	See Also *	Display	Folder Options	Folder Size	Fonts	Game Controllers	Intel(R) GMA Driv	Internal NIC Configura	Internet Options	Java
×	 Windows Update Help and Support 	1	Ċ		6		S	۹۹	i	Q
Excel 2003		Keyboard	Mouse	Network Connecti	Network Setup	Phone and Modem	Phone Monit	Power Options	Printers and Faxes	QuickTime
		9	9	1	۲	Σ	O,	<u>s</u>		
PowerPoint 2003		Regional and La	Scanners and Ca	Scheduled Tasks	Security Center	SigmaTel Audio	Sounds and Audio De	Speech	System	Taskbar and St
W		82	3	6	2					
Paint		User	Windows	Windows	Wireless	Wireless	Почта			
		100001110	curappace							
Set Program Access	and Defaults									
💖 Windows Catalog										
Nindows Update										
WebMoney Keeper (Classic 3.6.0.6								B My Con	nputer ///
💼 Programs	•									
😪 Favorites	•									
Documents										
Settings	Control F	'anei								
Help and Support	S Network	Connections								
@ Run	Printers a	and Faxes	1							
🔽 Log Off Vadik		and start Me	anu -							
Turn Off Computer										

- b.
- Setting up the Firewall: Click "Advanced" tab then "Settings" button




d. Repeat for the "3183" and "3184" ports

	Advanced Settings	? ×	
	Services ICMP		
	Select the services running on your netvaccess.	vork that Internet users can	
	Services		
	FTP Server		
	Internet Mail Access Protocol Versi	on 3 (IMAP3)	
	Internet Mail Access Protocol Versi	on 4 (IMAP4)	
	Internet Mail Server (SMTP)		
	Post-Office Protocol Version 3 (PO	P3)	
	Remote Desktop		
	Secure Web Server (HTTPS)		
	Telnet Server		
	Web Server (HTTP)		
	,	1	
	Add Edit	Delete	
		OK Cancel	
Service Settin	igs ?×	Service Settings	? ×
Description of service:	:	Description of service:	
Tesseral Network Key	y 2	Tesseral Network Key 2	
Name or IP address fi	or example 192 168 () 12) of the	Name or IP address for exam	ole 192 168 () 12) of the
computer hosting this	service on your network:	computer hosting this service	
192.168.0.1		192.168.0.1	Note: 3182 is TCP
			3183, 3184 are UDP
External Port number f	for this service:	External Port number for this s	ervice:
3183		3184	C TCP C UDP
Internal Port number fr		Internal Port number for this a	
3183		3184	
10100			
	OK Cancel		OK Cancel

3. Questions and Answers:

a. Q: Network key monitor shows "blank" window

👳 Guardant Net Monitor	_ 🗆 🗵
Servers View Help	
\$2 ₽ ?	
Found servers:	

Please, try following:

- Check if the green indicator in the USB key is lit. If not, please, download and install the latest drivers.

- Try to reboot your server

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- Check your firewall (please see 2 in Section 18.6)
- **b. Q**: Tesseral 2D/Pro does not "see" the network key

	Outgoing Code:
	Error
-	
	Unable to connect the network server!
	Unable to connect the network server!
HASP k	Unable to connect the network server!

Please, try the following:

- Check your firewall (please see 2 in Section 18.6)
- Check the configuration in *gnclient.ini* file in Tesseral program directory