



RFDynamics

tNavigator release description

Moscow, 2016

1 tNavigator 4.2.6

In tNavigator 4.2.6 a new module of tNavigator PVT Designer is available. In PVT Designer it is possible to choose components, conduct experiments, load laboratory measurement data, execute an automatic matching of chosen parameters in accordance with measured data (regression) and create PVT tables.

1.1 tNavigator kernel

In tNavigator 4.2.6 kernel new options are supported for models in E100, E300, MORE, IMEX, STARS, GEM formats.

For models in E100 and E300 formats the following options are supported:

- For the group control mode it is possible to limit the surface water and gas production rate by the fraction of the corresponding phase injection rate (18 and 19 parameters of the keyword GCONPROD, and PBWS, PBGS values in parameter 2 of the keyword GCONPROD).
- The possibility to take into account the dependence of polymer adsorption on salt concentration (keywords ADSALNOD, PLYADSS).
- The possibility to take into account a passive tracer absorption (keywords TRROCK, TRADS).
- The possibility to generate horizontal pinchout connections via defining the pinchout threshold widths in X and Y direction, respectively (keyword PINCHXY).
- The use of keyword MULTREGT in SCHEDULE section is supported (multipliers are accumulated, i.e. the resultant multiplier is the product of previous dates multipliers).
- The compatibility setting to coarse grid calculations is supported (value 1 should be set for the parameter 141 of the keyword OPTIONS).

For models in MORE format:

- For the well gas inflow simulation the Russell-Goodrich (R-G) equation and pseudo-pressure (P-P) option are available (keywords GPP, MPGP, WGPP, WMPG, RG, WRG).
- The option AREA allowing to calculate the analytical aquifer productivity index is available (keyword AQWO).
- For the black-oil model the temperature expansion is supported (keywords THER, UOIL, UGAS, UWAT, UROC, THCO, THCG, THCW, THCR, OVVT, GVVT, TEMP).

For models in E300 format:

- The possibility to define the target or limit of the total molar rate is available (parameter 20 of the keyword WELLINJE).
- For simulations of isothermal compositional models several water components can be chosen (keywords WNAMEs, COMPW, PREFW, DREFW, VREFW, CREFW, WI, WMF, WMFVD, AQSTREAW).
- For isothermal compositional models three components asphaltene model is available. This model allows to simulate the variation of "mobile" pore volume caused by asphaltene deposition process (keywords ASPDEPO).

Data input-output. Reports:

- The possibility to save Maps in E100 binary format (the keyword RPTRST with parameters FOAMMOB, VELOCITY, VISC).
- The possibility to save binary SUMMARY files either separately for each reporting time step, or as a unified one (keywords UNIFOUTS, MULTOUTS).

Special options:

- The choke can be set and the fluid flow pressure through the choke using correlation formulas can be computed (the keyword NETCHOKE).
- For water-gas two phase model (E100 format) it is possible to define phase relative permeability using Corey and Let correlations (keywords COREYWG, LETWG).
- The well geometry is taken into account when calculating a bottom hole pressure via a wellhead pressure using VFP correlations (keywords WELLINCL, WELLDATA, WELLBRANCH).
- The geometry of analytical aquifer connection to the reservoir can be detailed defining a connection on specified depth, to the reservoir bottom, to the reservoir boundary and different ways of productivity index calculation (the keyword AQUGP).
- The possibility to deactivate blocks by their depth value is available (the keyword DEACDEPT).
- For hydraulic fracturing simulations it is possible to create User Maps and User Cuts using virtual perforations (wmvc function) allowing to visualize blocks with virtual perforations generated by hydraulic fractures.
- The possibility to create User Maps and User Cuts picking out all blocks which a well trajectory passes through (function wmtc).

MPI version:

- IDW interpolation method can be used.

1.2 Model Designer

In tNavigator 4.2.6 Model Designer the following features are added:

- The possibility to save and run WorkFlows, i.e. to create, copy, modify and start a calculation sequence.
- Templates are available for Well correlation profile (Well Section): it is possible to create, copy and edit templates (it is possible to move the objects on panels and change their settings).
- It is possible to load objects in the following formats:
 - Well trajectory, wellhead, markers, events, Well Logs: Landmark OWX files *.asc;
 - Horizons: Surfer 7 GRD (Bin) Format, Z-Map Plus Format, GXF-3 Format;
 - Faults: Surfer 7 GRD (Bin), Surfer BLN file, Landmark Fault 3d;
 - Polygons: Surfer BLN files, TKS Polygons.
- It is possible to interpolate 2D Maps via Wells Attributes using the following methods: IDW, Kriging, Gauss Simulation, Least Squares.
- For Well Section the scale can be defined manually.
- Cross-Sections can be visualized in 3D mode as planes.
- Well Logs, Horizons, Markers, Maps, Points Sets and Wells Attributes can be presented via Histograms.
- The Statistics table for Histograms is available.
- Advanced properties are available for Histograms and VPC.
- User section SCHEDULE can be loaded into Model Designer (data are visualized in Well Data. Rules).
- The possibility to rearrange rules in the Rules tree is available (date and rule execution order can be changed).
- The possibility to define well control on THP and VFP tables for injection wells is available.
- The possibility to choose oil as injected fluid for injection group control is available.
- The well construction on Well Section can be visualized and modified.
- The possibility to load measurement data for VFP tables is available, after that matching for VFP tables on measured data can be done.
- The possibility to create VFP tables taking into account the well trajectory is available.

1.3 PVT Designer

In tNavigator 4.2.6 PVT Designer:

- The Graphical user interface was optimized.
- New experiments are available (Separator Test, Swelling Test, Compositional Grading).
- The phase phase envelope can be plotted and the critical mixture point can be determined.
- For all experiments it is possible to define measurement data and automatically match chosen parameters according to defined laboratory data.
- New component grouping algorithms (lumping) automatically computing component weight coefficients in pseudo-components are available.
- The obtained results can be exported in E100 and E300 format files.

1.4 Assisted History Matching

In tNavigator 4.2.6 Assisted History Matching module the following features are added::

- The Plackett–Burman experimental design method is implemented.
- The optimization algorithm can be started from the initial population defined by the user.
- The algorithm may be set up to terminate when the objective function does not improve during the defined number of iterations.
- Automatic restrictions are added to scenario calculating possible relative permeability end points values (e.g., $SWL \leq SWCR$).
- For optimization algorithms in assisted history matching it is possible to choose historical data that will be taken (or not) into account. I.e. the possibility to choose the historical points for objective function calculation is available.
- PLT measurements can be used in Assisted History Matching.

1.5 Graphical User Interface

In tNavigator 4.2.6 Graphical User Interface:

- Logarithmic scale can be used for Crossplots Graph Templates.
- Arbitrary icons for wells on 2D maps can be loaded (Preferences. Well and connection icons).

- Fonts and Units can be set in Bubble Maps.
- In the Schedule table new tabs with keywords defining Multisegment Wells, Economic Limits, Drilling and Workovers are available.
- ALQ graph for network is visualized (Analysis Tab).
- Visualization of Flow graphs for numerical Aquifers is available.

1.6 Compatibility with previous versions

In tNavigator 4.2.6:

- The option allowing pressure to increase going up the network is not supported anymore (option INCREASENETWORKP of the keyword TNAVCTRL).

2 **tNavigator 4.2.5**

2.1 **tNavigator kernel**

In *tNavigator 4.2.5* new kernel options are supported for the following model formats: E100, E300, IMEX, STARS, GEM.

For models in E100 and E300 format the following options are supported:

- The possibility to use INSTANT option for Coal Bed Methane Model (parameter INSTANT of the keyword CBMOPTS).
- The possibility to set the control mode for injectors that work in the history matching mode: injection rate control or BHP control (parameter 12 of the keyword WCONINJH).
- The possibility to control the inheriting process of the threshold pore volumes (MINPV or MINPVV) for LGR blocks (46-th parameter of the keyword OPTIONS).
- The possibility to set tracer decay half-life (the keyword TRDCY).

For models in E100 format the following options are supported:

- Foam modeling option (keywords FOAM, FOAMOPTS, FOAMADS, FOAMROCK, FOAMDCYW, FOAMDCYO, FOAMMOB, FOAMMOBS, FOAMMOBP, SFOAM, WFOAM).
- The possibility to set several gas producers, that are opening from the drilling queue when the sales gas production rate falls below the minimum limit (the keyword WGASPROD).

For models in E300 format the following options are supported:

- For isothermal compositional models Residual oil modeling option is available (keywords SOR, SOILR, ROMF, SOROPTS).
- For isothermal compositional models 2-component Asphaltene option is available (keywords ASPHALTE, ASPP1P, ASPREWG, ASPP2P, ASPPW2D, ASPFLRT, ASPVISO, CATYPE).

For models in IMEX format the following options are supported:

- The possibility to set bubble points pressure as a map for models with equilibrium (VERTICAL DEPTH_AVE) initialization (PB ALL).

For models in GEM format the following options are supported:

- The possibility to set model geometry via specifying blocks tops (the keyword CORNERS).

**Data input-output. Reports:**

- The possibility to dump RSM-file with simulation results is available for all model formats (E100, E300, IMEX, STARS, GEM, MORE).
The keywords SEPARATE and RUNSUM are supported for models in formats E100, E300. For console version the command `--ecl-rsm` can be used. Dump of the RSM-file can be requested from graphical user interface (File. Reports) and from remote graphical user interface (in Model Queue).
- The possibility to create a template to dump graphs in E100 binary format and RSM-file is available. These templates can be saved and used in several models (also for models in not E100 input syntax). The template can be used in Model Queue for cluster calculations.

Special options:

- The possibility to generate PVT tables automatically via the input component properties is available for black oil models in format E100 (the keyword PVTGEN). PVT tables are created and used in simulation. In this case in the PROPS section component properties should be specified in E300 format instead of PVT-tables.
- The possibility to set model geometry via specifying blocks tops is available for model in formats E100, E300 (the keyword CORNERS). The GRID files is dumped automatically for models with the keyword CORNERS.
- The possibility to control foam/tracer participation in decay process (option DECAFY_MODEL of the keyword TNAVCTRL).

2.2 Model Designer

In tNavigator 4.2.5 the following features are added to Model Designer:

- The possibility to create several Correlation profiles for Well Section is available. Use Well Selector to pick wells on 2D view.
- The possibility to "put" horizon on markers is available (Calculations. Interpolation. Discrepancies Elimination).
- The possibility to load horizons and faults in the format Surfer 7GRD is available.
- The possibility to load polygons and faults in the binary format SurferBln is available.
- The possibility to choose and delete objects from the object list is available, the possibility to delete all objects from the folder (use Shift to choose several objects).
- The possibility to calculate Residuals for horizon interpolation. Residuals are calculated automatically as Wells Attributes (difference between marker depth and the point where well trajectory intersects a new horizon). Visualization is available on 2D Maps, Wells Table and Statistics.

- The possibility to add wells on 2D Maps has been added. The following drawing options are available:
 - Drawing on the selected depth.
 - Intersection with horizon.
 - Well head.
 - Bottom hole.
- The possibility to calculate geometric volume in a specified polygon between two surfaces (User Maps. Auxiliary Calculations. Assign between surfaces).
- The possibility to average log-data for wells between markers is available: netpay, porosity, permeability, NTG and other (Well Attributes. Average Log Between Markers).
- The possibility to create special 2D Maps is available: top and bottom of the collector, netpay, porosity, permeability, NTG and other (2D Maps. Auxiliary Calculations. 2D Map by 3D Map).
- The possibility to replace PVT and RP correlations by generated tables. Then tables can be edited manually (Replace by generated tables button).
- The possibility to load capillary pressure to existing RP correlations (Import. Load Pcap tables. Load the file with keywords SWOF, SGOF).
- The possibility to load RP data defined by Corey correlation (COREYWO, COREYGO) and capillary pressure in table form (SWOF, SGOF).
- New operator is available in arithmetics: IF-THEN-ELSE-ENDIF. if operator with brackets {} is not supported in this version and further.
- In the table with User Keywords (Well Data. Rules. User Keywords) the following options are available:
 - the possibility to move lines (data of the event is changed according to the new position);
 - copy the line with keyword (Right mouse click. Duplicate Keywords);
 - Keyword Editing. The pop-up hint for all parameters is available in all editing modes;
 - the possibility to switch between Table and Text form for keyword Adding and Editing.
- New options are available to create Assisted History Matching project from Model Designer:
 - A scenario to create variables for relative permeabilities defined via Corey correlation is available.

- The possibility to use interpolation parameters as variables is available.
- Variables can be used in Calculator.

2.3 Assisted History Matching

In tNavigator 4.2.5 Assisted History Matching module the following features are added:

- The new approach to create variables to edit relative permeabilities for models with many saturation regions is implemented.
- In the scenario to create variables from graphical user interface (for end-point scaling and relative permeabilities defined via Corey correlations): the possibility to set one variable for several regions is available.
- The possibility to combine different type of objects in the objective function is available (add terms in objective function dialogue).
- The possibility to change the ranges of several variables at the same time.

2.4 Graphical User Interface

In tNavigator 4.2.5 Graphical User Interface the following features are added:

- New operator is available in arithmetics: IF-THEN-ELSE-ENDIF (can be used in User Maps, User Cuts, ARITHMETIC keyword in the .data-file).
- Visualization of the Cross-Sections is available in 3D view (3D Map). A Cross-Section can be visualized as a plane in 3D view (Check Show Cross-Section).
- The possibility to create templates for Bubble Maps is available. Bubble Maps can be visualized for wells, groups, network nodes. These templates can be exported and used in other models.
- Well Filter has been improved. Filter to choose group of wells or network nodes is available. Groups and nodes that are selected are visualized on 2D Maps.
- The possibility to manage the visualization of group structure and surface network is available. Press right mouse click on the object to add or remove it itself (of with subordinate objects) from visualization filter.
- Well Selection option has been improved. Wells can be selected on 2D Map: one by one, by rectangle in inside the curve of any arbitrary shape (use Shift, Ctrl to select wells in several zones, one by one mode). The selected wells can be used in the Well Filter.
- The possibility to smooth well trajectories on 3D Maps and 2D maps is available (Document. Preferences. Well Options).

- The visualization of the map of linear solver residual is available (Calculated Maps. Number of Convergence problems). This map should be requested via the option CONVERGENCE_PROBLEM_NUM of the keyword TNAVCTRL.

2.5 Licenses and License server

In tNavigator 4.2.5:

- The licensing module has been modified to optimize the resources consumption and reduce delays.
- The statistics about current license utilization is available in the format Open iT LicPoll.
- New license type is available – Large Data Set. This license can replace any number of Black Oil licenses (more than 8) for corresponding tasks.

3 tNavigator 4.2.4

3.1 tNavigator kernel

In tNavigator 4.2.4 new kernel options are supported for the following model formats: E100, E300, IMEX, STARS, GEM.

Reservoir Coupling support:

- The possibility to couple models with different physics is available: black oil, compositional, thermal. Models can be in different formats: E100, E300, IMEX, STARS, GEM.
- The possibility to couple models with common surface network is available (keywords for Standard network option are available).

For models in E100 and E300 format the following options are supported:

- The possibility to update skin-factor for connections (the keyword CSKIN).
- The possibility to use an operation MAXR when a maximum rate limit is violated – maximization of the future production rate by setting the reinjection fraction limit to 1 (parameter 5 of the keyword GCONSALE).
- The possibility to set the value of gas consumption for extended network nodes (the keyword NCONSUMP).
- The possibility to activate pressure modifications to achieve initial equilibration (option QUIESC the keyword EQLOPTS).
- The possibility to use automatic compressors for standard network option (parameters 1-3 of the keyword GASFCOMP).
- The possibility to use the following group control mode – production balancing fraction (parameter PRBL of the keyword GCONPROD).
- The possibility to prevent the well changing from rate control to THP control when it is constrained to operate on the unstable side of its VFP curve (parameter 4 of the keyword WVFPEXP).
- The possibility to set minimum interval between gas lift optimizations (parameter 3 of the keyword LIFTOPT).

For models in E300 format the following options are supported:

- The possibility to set the distribution of CO₂ component between water and hydrocarbon phases via the table data as a function on pressure (keywords CO2SOL, SOLUBILI, RSWVD, RSW).

- For thermal models the control by water saturation pressure and temperature can be used (options SATT and SATP of the keywords WCONPROD, WELLPROD).

For models in IMEX, STARS, GEM format the following options are supported:

- The possibility to use analytical Fetkovich aquifer (the keyword AQMETHOD (*FETKOVITCH)).
- The possibility to connect analytical aquifer to the reservoir boundary (the keyword AQUIFER (*BOUNDARY, *RESBND)).

For models in IMEX format the following options are supported:

- The possibility to use the model of polymer flood (keywords MODEL POLYMER, PADSORP, PPERM, PMIX LINEAR, NONLINEAR, TABLE, VELTABLE, PREFCONC, PVISC).
- The possibility to set block and direction dependent pressure gradient thresholds (keywords PTHRESHI, PTHRESHJ, PTHRESHK).
- The possibility to set grid corner point geometry (the keyword CORNERS).

For models in GEM format the following options are supported:

- The possibility to set different ways to calculate the density of the stock-tank oil and gas after separator (the option STREAM-DEN in the keyword SEPARATOR (*EOS, *GASLAW)).

Special options:

- The possibility to use modified Corey correlations to set relative permeabilities (COREYWOMOD, COREYGOMOD).
- For models in E100 and E300 formats the new operation can be used when the group limit is exceeded (option TARG in the 7-th parameter of the keyword GCONPROD). The option works analogously to the RATE option with the following difference. When RATE option is specified, then the corresponding limit is always checked, when TARG option is specified, then the group limit is removed when it can't be performed.
- The fully implicit option can be used to calculate analytical aquifers (the keyword AQUOPTS (FI, FI_ELIM_AQ_VAR)).
- The possibility to set model initialization and calculation logic compatibility with different versions of other simulators (option COMPATIBILITY of the keyword TNAVCTRL).
- The possibility to use the model with zero number of time steps as a base model for restart (forecast).

3.2 Model Designer

In tNavigator 4.2.4 the following features are added to Model Designer:

- New options are available to create Assisted History Matching project from Model Designer:
 - A scenario to create variables is available – equilibration parameters (contacts' depths).
 - The visualization of analytical data is available (crossplots, Pearson correlation, Tornado chart).
- The possibility to use separators in PVT experiments option is available.
- The visualization of the keywords loaded from SCHEDULE section is available for E100 format. User can edit existing keywords and add new keywords.
- The possibility to add arbitrary time steps (Time step editor).
- The possibility to set the coordinate reference system (Datum). The system can be set in Document, Settings. Coordinate reference system can be found using its name, country or EPSG code. In the tab Detailed Information the datum information and the ellipsoid is provided.
- This visualization of Contour lines is available on 2D Maps (check Show Contour lines, Color by Contour lines).
- The following options are available for data loading:
 - load grid in gridecl format (in the current version the grid can be loaded without LGR);
 - the possibility to merge curves with the same names when curves are loaded.
- Facial Analysis is available (User Maps. Facial Analysis can be used to create facies, then reservoir properties maps can be created using facies. Different interpolation parameters can be set in different zones).
- The following options are available on Well Section tab:
 - The date of measurement can be visualized for LOG curves (LAS, RFT/MDT) (can be unchecked in Properties).
 - One LOG curve (LAS, RFT/MDT) can be visualized at the same time at different dates and with different visualization settings. Duplicate the curve and set in its Properties the number of date you need and other visualization parameters.
 - The scale with block numbers is available.
- The possibility to edit maps on 2D view via Brush button is available.

3.3 Assisted History Matching

In tNavigator 4.2.4 Assisted History Matching module the following features are added:

- A new scenario is available to create variables from graphical user interface – Multiply Permeability by Layers.

3.4 Graphical User Interface

In tNavigator 4.2.4 Graphical User Interface the following features are added:

- The possibility to move the points of well trajectory using mouse is available.
- The visualization of Bubble maps for groups and network nodes is available.
- In the option Schedule (tabs Well Definition, Well Production, Other operations, All operations) the pop-up tips for keywords are available.
- The possibility to reload model and start calculations immediately is available (Document. Reload model and Run Calculations).
- The possibility to cut wells' trajectories by depth (Z direction) is available (for visualization) (Document. Settings. Well Options. Check the box Cut Trajectory by Depth).
- The following options are available on Well Section tab:
 - The date of measurement can be visualized for LOG curve (LAS, RFT/MDT) (can be unchecked in Properties).
 - One LOG curve (LAS, RFT/MDT) can be visualized at the same time at different dates and with different visualization settings. Duplicate the curve and set in its Properties the number of date you need and other visualization parameters.
 - The scale with block numbers is available.

3.5 Licenses and License server

In tNavigator 4.2.4:

- The possibility to use multiple licenses on a local dongle is available. Thus, it is possible to have more than one for each type of the license on the dongle. So if you have multiple licenses then the corresponding number of models can be calculated at the same time.

4 **tNavigator 4.2.3**

4.1 **tNavigator kernel**

In *tNavigator 4.2.3* new kernel options are supported for the following model formats: E100, E300, IMEX, STARS.

In this release there is a first implementation of Reservoir Coupling option for integrated calculation of several models using common group controls.

Also in this release there is a first implementation of compositional models in **CMG GEM** format.

Reservoir Coupling support:

- Option is set via the keywords SLAVES, GRUPMAST, GRUPSLAV.
- Several SLAVE models are integrated via one MASTER model.
- In this release only black oil models can be used in coupling in all supported data formats: E100, MORE or IMEX.
- MASTER model must be in E100 format. It can be full-featured model or simple fake model with one active grid block.
- There is fully implicit model calculation. Equations from all models are combined to one common system of equations that describes the whole integrated reservoir.

For models in GEM format the following options are supported:

- The possibility to use cubic equation of state: Soave-Redlich-Kwong equation or Peng-Robinson equation (the keyword MODEL).
- The possibility to set multiple equations of state is available (EOS) (the keywords EOSSET, EOSTYPE). In each region component properties can be set (the keywords MW, PCRIT, VCRIT, TCRIT, ZCRIT, BIN, PCHOR), coefficients of equations of state (the keywords AC, OMEGA, OMEGB), and the volume shift (the keyword VSHIFT).
- HZYT and PEDERSEN correlations can be used for hydrocarbon phases viscosity simulation (the keywords VISCOR, VISVC, MIXVC, VISCOEFF).
- Separators can be set for resources calculation (the keyword SEPARATOR) and for wells (the keyword WELSEP).
- Fully implicit and adaptive implicit (the keyword AIM) methods can be used.

For models in E100 and E300 format the following options are supported:

- The possibility to set maximum allowed number of open wells subordinate to the group for which economic limits are set (parameter 9 of the keyword GECON).

- The possibility to set an interpolation method for Artificial Lift Quantity ALQ in VFP tables (the keyword VFPTABL).
- Autonomous inflow control devices (ICD) can be used in multisegment wells (the keyword WSEGAICD).
- The possibility to set the time limits taken for well automatic workovers when group economic limits are violated (the keyword WORKLIM).
- The possibility to set Artificial Lift Quantity (ALQ) that is used in the pressure loss calculations for the branch in extended network (parameter 4 of the keyword BRANPROP).
- The possibility to set well cutback limits (the keyword GCUTBACK).
- The possibility to set the phase for which group's guide rate is calculated (parameter 10 of the keyword GCONPROD).
- The possibility to set the decrement for contract gas rate and conditions to cut group's rate in DCQ option – Gas Field Model (the keywords GASFTARG, GASFDECR).
- The possibility to set guide rate wells' values (the keyword WELLGR).
- The possibility to set the way to extrapolate VFP table values for water fraction, gas fraction and ALQ (parameter 5 of the keyword WVFPEXP).
- The possibility to set the multiplier which is used to calculate the matrix-fracture flows in dual porosity models (the keyword MULTMF).
- The possibility to set transmissibility multipliers for all cells in specified faults in schedule section (the keyword MULTFLT).

For models in E100 format the following options are supported:

- The possibility to use polymer shear thinning/thickening logarithmic model (the keyword PLYSHLOG).

For models in E300 format the following options are supported:

- The possibility to set the oil viscosity dependence on pressure via PVCO table for thermal models.
- The possibility to set temperature, pressure, specific enthalpy rate and steam quality of the injected fluid for thermal models (parameters 21-24 of the keyword WELLINJE).

For models in IMEX, STARS, GEM format the following options are supported:

- The possibility to smooth relative permeabilities (parameters LINEAR, QUAD, CUBIC of the keyword SMOOTHEND).

- The possibility to set water saturation below water-oil contact (the keyword WOC_SW).
- The possibility to set reference pressure for pore volume calculation the first block of the region (option REFFIRST of the keyword ROCKOPTS).

For models in STARS format the following options are supported:

- IDEALGAS option is available.

Special options:

- A new tNavigator data format is implemented. This format is an extension of E100, E300 formats that provides more convenient definition of well data (to set trajectories in X, Y, Z, MD and perforations in measured depth) (the keywords WELLTRACK, COMPDATMD).
- The possibility to smooth relative permeabilities for models in E100 and E300 (the keyword KRSMOOTH).
- The new keyword AQUOPTS is implemented to set parameters for analytic aquifers calculation for models in format E100 and E300.

Data input output:

- A new option KEYWORDS_SPACE is added to the keyword TNAVCTRL for models in format E100 and E300. If this setting is set to 1 the keywords that are written after the space symbol at the beginning of the line are read. By default this option is not used, these keywords are ignored, and the corresponding message will be visualized.
- A new option LONGNAMES is added to the keyword TNAVCTRL for models in format E100 and E300. If this setting is set to 1 then tNavigator will read well names that are longer than 8 symbols. For default without this setting there is a cut for names that are longer than 8 symbols.
- The possibility to save the reporting parameters for wells, groups in binary files in E100 format export at calculation time steps when the model is calculated by tNavigator console version. Option is used for default. It can be switched off using the keyword RPTONLY. If E100 binary files are saved from graphical user interface they will be saved at reporting (not calculation) steps.
- The output of the threshold pressure between equilibration THPRES to .log-file is available.

4.2 Model Designer

In tNavigator 4.2.3 the following features are added to Model Designer:

- The possibility to save model in a new tNavigator data format is implemented. This format is an extension of E100, E300 formats that provides more convenient definition of well data (to set trajectories in X, Y, Z, MD and perforations in measured depth) (the keywords WELLTRACK, COMPDATMD).
- The possibility to visualize and edit well trajectories, markers and Wells Logs in table form.
- The possibility to create PVT tables for oil and gas (black oil models) using input compositional properties. The following options are supported:
 - Component sets can be created using the standard list or can be imported as a text file.
 - CCE, DLE, CVD experiments can be simulated for a component set; the critical point of the mixture can be calculated; bubble point pressure dependence on temperature can be build.
 - The results of experiments are visualized as graphs and tables.
 - PVT tables for oil and gas can be calculated via a component set and chosen parameters.
 - PVT tables are visualized as graphs and tables.
 - PVT tables can be added to the model, or exported to a text file.
- The possibility to analyze component properties: compositional calculator (phase envelope) and graphs (viscosity, mass density, molar density). When component lumping (group components) is used you can compare results on phase envelope and graphs before and after lumping.
- The possibility to find wells on 2D, 3D maps and Well Section is available.
- The possibility to create sub folders in object tree is available.
- The possibility to sort and manually change the order of objects in the tree is available.
- The possibility to set Well Logs loading settings (including units, palette type etc).
- Statistics is available for Well Log visualization on 3D Map.
- The possibility to add markers where the wells' trajectories intersect a horizon.
- The possibility to do local horizon editing: pull up the horizon to the selected markers on selected wells.
- The possibility to create grids via faults and horizons and taking into account the impact of faults.

4.3 Assisted History Matching

In tNavigator 4.2.3 Assisted History Matching module the following features are added:

- Response surfaces method is implemented (Proxy models).
- Modified Particle Swarm Optimization method is implemented (FlexiPSO).

4.4 Graphical User Interface

In tNavigator 4.2.3 Graphical User Interface the following features are added:

- The RFT/MDT Mismatch Table is visualized for wells and zones (layers' groups). The table is available in Graphs. If zones (reservoirs) are set via the keyword ZONES then mismatches for each zone (reservoir) will be available on this tab as well.
- The possibility to save a zip-archive with a model (available in Document menu). Model .data file and all included files will be saved in separate zip-archive. This functionality can be used to zip the model with a lot of included folders with data and a lot of included files.
- The visualization of OILVISCT, GASVISCT is available.
- The visualization of group hierarchy on 2D maps is available.
- The possibility to save loaded well data to tNavigator format (the keywords WELLTRACK, COMPDATMD).
- The new mode for time axis visualization is available for models with very small time steps. Choose in Graphs Settings the data format – HH:MM:SS.xxx.

4.5 Compatibility with previous versions

- The format of results files has been changed. tNavigator version 4.2.2 and earlier are not visualizing results of 4.2.3 calculation.

4.6 Licenses and License server

In tNavigator 4.2.3:

- Licensing for Reservoir Coupling option is supported (to do integrated simulation of several models using a common group controls).
- License server can be installed with password protection.

5 **tNavigator 4.2.2**

5.1 **tNavigator kernel**

In tNavigator 4.2.2 kernel new options are supported for the following model formats: E100, E300, STARS.

Calculations speed-up, accuracy settings:

- The new speed-up option WELLDENWEIGHT of the keyword RUNCTRL is available. It reduces oscillations of wellbore mixture density, thus reducing well oscillations and improving convergence and calculation speed. This option may be used for all models formats.

For models in E100 and E300 format the following options are supported:

- Grid coarsening option is available (the keyword COARSEN).
- The possibility to prevent well connection pressures from falling below atmospheric pressure is available (parameter 47 of the keyword OPTIONS).
- The actions for wells can take place after a defined time period has passed (the keyword DELAYACT).
- Reference depth can be specified independently for each region in FIP family (the keyword DATUMRX).
- The surface tension can be set as a function of salt and surfactant concentration in models with salts and surfactants (keywords ESSNODE, SURFSTES).
- Special inflow equations for wells are available: Russell-Goodrich equation (R-G option) and P-P (generalized pseudo-pressure equation) (parameter 8 of the keyword WELSPECS).

For models in E100 format the following options are supported:

- Total molar rate target can be used as a well control or a limit (option TMRA of the keywords WCONPROD, WELTARG).
- Capillary pressure in systems water-oil and gas-oil can be set as functions of surface tension (option SURFTENS of the keyword SATOPTS; keywords STOW, STOG).

For models in E300 format the following options are supported:

- Generalized pseudo pressure option is available (option GPP, parameter 5 and 6 of the keyword PICOND).
- For compositional models Pedersen viscosity correlation is supported (keywords PEDERSEN, PEDTUNE, PEDTUNER).

For models in STARS format the following options are supported:

- Aquifer can be connected to the reservoir using the keyword BOTTOM.

Special options:

- VFP tables can be generated for producers via correlations (the keyword VFPCORR) in compositional models.
- The fully implicit calculation of API is implemented (the keyword TRACEROPTS). In the version 4.2.2 for salts and API fully implicit calculation is used by default. To use semi-implicit calculation (default in previous versions) one need to use flag EXP in the keyword TRACEROPTS.
- Well lists can be used (WLIST) in the second parameter of the keyword ACTIONC.
- BLOCK(x,y,z) function can be used in the keyword ARITHMETIC in sections PROPSOLUTION.
- MAPAXES is taken into account when coordinates X, Y, Z are defined in BLOCK (X, Y, Z are set in the global coordinate system).
- ARRXXX maps from previous sections can be used in the keyword ARITHMETIC.

MPI version:

- Grid coarsening option is available (the keyword COARSEN).
- Blocks from LGR can inherit rock property automatically from global grid (the keyword LGRCOPY).
- Non-neighbor connection transmissibility values between blocks in any two grids can be set (the keyword NNCGEN).

5.2 Model Designer

In tNavigator 4.2.2 the following features are added to Model Designer:

- Several model variants can be created.
- Calculation results of different model variants can be loaded automatically.
- Forecast model can be created; the possibility to edit forecast period and wells' control modes on the first forecast time step is available.
- Economical limits can be edited in the Well Properties dialogue.
- A compass and a scale are available on the visualization panel.
- Bubble maps are available on 2D maps.

- The local grid editing is available using selected markers and radius.
- Statistics for horizons is available.
- The possibility to select the length units separately for XY and for Z is available in data loading (RESCUE, well data).
- Polygon union operation is available.
- Filter for horizon can be used using polygon.
- Interpolation for 3D maps using VPC and selected map is available.
- 3D permeability map can be interpolated using porosity map and permeability distribution.
- Trends can be used in different interpolations of 3D maps: any property (trend property), VPC (2D-map + trend), core data (porosity Log, porosity precision).
- The result of interpolation can be cropped using the bounds of input data.
- In Well Section logarithmic scale is available.

5.3 Assisted History Matching

In tNavigator 4.2.2 Assisted History Matching module the following features are added:

- Particle Swarm Optimization method is implemented (PSO).
- Differential Evolution method is optimized for a small amount of simulation launches. Select Local to use this option. If you can launch simulator a lot of times Global can be used.
- Optimization for NPV is available (net present value).
- Typical HM scenario is available from GUI to vary end-points arrays (SWCR, KRO etc.). Experiments are created automatically.
- Typical HM scenario is available from GUI to vary faults' transmissibility multipliers (MULTFLT). Experiments are created automatically.
- The possibility to assign variable values from specific number of values (defined manually) is available.
- The series of experiments can be created for different geological realizations.

5.4 Model Queue. Remote GUI

In tNavigator 4.2.2 Model Queue and Remote GUI module the following features are added:

- Model Queue is integrated with Model Designer. Calculations can run on cluster.
- The possibility to start calculation from the selected time step is available.

5.5 Graphical User Interface

In tNavigator 4.2.2 Graphical User Interface the following features are added:

- The visualization of surface network is available (NETWORK). Use Show Network nodes on 2D map.
- The possibility to create Templates for Cross plots is available; for example for Hist. vs. Calculated graphs. On Graphs Templates switch from Graphs to Crossplots.
- The regions maps (FIPNUM, SATNUM etc.) can be used as a Cut for visualization.
- The histogram for palette is available (shows the distribution of selected parameter).
- The possibility to group virtual and real well connections is available (for hydraulic fractures). These groups are visualized in objects list and in Well Filters.
- The multipliers for units can be fixed on Graph Templates (thousands/millions).
- User defined arrays ARR can be visualized in View Results mode and they can be used in map arithmetic command line (User Maps and User Cuts).
- Maps PINCHNUM and ENDNUM can be used in map arithmetic command line (User Maps and User Cuts).
- In Load Well Data dialogue the date can be set in the format of number of days from the starting date (select this option in the corresponding box).
- In Load Well Data dialogue the historical data can be applied to the previous time step (select this option in the Units Settings tab).
- The possibility to expand/collapse all child objects in the object tree for Graphs is available via the right mouse click on the object.
- Transmissibilities TRANX (Y,Z) are visualized and saved in the INIT file with transmissibility multipliers applied - MULTX(Y,Z), MULTX-(Y,Z), HMMULTX(Y,Z), HMMULTX-(Y,Z), HMMLTXY.

5.6 Compatibility with previous versions

- The format of results files has been changed. tNavigator version 4.2.1 and earlier are not visualizing results of 4.2.2 calculation.
- To save and split the model it is necessary to check in the Settings. Models. Write Initial Maps). Recording of initial maps is not done for default now to speed-up models' opening on slow shared disks and to reduce the size of the folder with calculation results.

5.7 Licenses and License server

In tNavigator 4.2.2:

- Histograms of the licenses usage are available in the web interface of the license server. For each module there is a separate histogram. It shows the percentages of time during the indicated time period when certain number of licenses was used. 0 Licenses were occupied during this percentage of time, 1 license - during this the percentage of time, etc. up to N - the number of licenses of this type.

6 tNavigator 4.2.1

6.1 tNavigator kernel

In tNavigator 4.2.1 kernel new options are supported for the following model formats: E100, E300, STARS. New option is available – VFP table generation according to the selected correlation.

Calculations speed-up, accuracy settings:

- Adaptive implicit method AIM is supported for thermal models in E300, STARS format.

For models in E100 and E300 format the following options are supported:

- User defined tables UDT can be used to assign values to user defined quantities (the following interpolation types can be used: NV, LC, LL).
- User defined quantities can be specified for well segments in UDQ keyword (for example, SOFR etc.).
- A control or limit value for the well can be increased or decreased for the specified value (the keyword WTADD).
- Scale deposition model: the cumulative effects of scale deposited around the well connections and the resulting degradation of the productivity index due to sea water injection (keywords SCDPDIMS, SCDATAB, SCDPTAB, WSCTAB (parameters 1-3)).
- Segmented model of density calculations can be used in BRINE option (parameter 12 SEG of the keyword WELSPECS).
- The threshold pressures for flow in each direction between equilibration regions can be different (option IRREVER of the keyword EQLOPTS).
- Non-neighbor connections across cells deactivated by MINPV can be created even if thickness exceeds threshold value (option GAP of the 2-nd parameter of the keyword PINCH).

For models in E100 format the following options are supported:

- Gas consumption rate and gas import rate can be specified via UDQ (parameters 2 and 3 of the keyword GCONSUMP).
- The possibility to apply maximum rate at which the solution gas-oil ratio is allowed only in blocks with free gas (option FREE 2-nd parameter of the keyword DRSDT).

For models in E300 format the following options are supported:

- The possibility to modify the Stone I three-phase oil relative permeability (the keyword STONEPAR).

- The possibility to define each component fraction to sale or fuel (4-the parameter of the keyword GRUPSALE, GRUPFUEL).

For models in STARS format the following options are supported:

- Option ISOTHERMAL can be used (energy conservation equation is not imposed in model. As a conclusion, grid cell temperatures will not change from their specified initial values).

Special options:

- New option is available – VFP table generation for producers according to the selected correlation (the keyword VFPCORR). The following correlations can be used:
 - PA – Petalaz & Aziz,
 - HB – Hagedorn & Brown,
 - O – Orkiszewski,
 - G – Gray,
 - AGF – Aziz,
 - Govier & Fogarasi,
 - MB – Mukherjee & Brill.
- An implicit calculation of passive tracer is available for black oil and compositional models and for waters with different salinities simulation (the keyword TRACEROPTS).
- Each block can have its own primary variable for thermal models in E300 and STARS format (option MIX of the keyword TFORM). Variables are chosen automatically by tNavigator
- A new option of console version is available: --restart, it continues calculation from input step or last calculated step if input step is not calculated.

MPI version:

- Splitting of hybrid models is available.

6.2 Model Designer

In tNavigator 4.2.1 the following features are added to Model Designer:

- Local grid refinement LGRs can be added: refinement along well trajectory, connections, in the specified box.
- Wells' perforations can be edited (Ctrl+click on the well or Edit Perforations on the Well Section).

- New wells and sidetracks can be added (Alt+click on the map).
- The possibility to create aquifers is available (set geometry and properties to Fetkovich or Carter-Tracy aquifer).
- Historical data is visualized on Graph Templates immediately when it is loaded to the project.
- The possibility to add well controls is available.
- The possibility to add group controls is available.
- The possibility to add economic limits for wells is available.

6.3 Assisted History Matching

In tNavigator 4.2.1 Assisted History Matching module the following features are added:

- An objective function can be set manually using UDQ.
- RFT measurements made before zero time step are assigned to zero time step and compared with the initial reservoir pressure.
- A comment can be added to each new experiment in the corresponding box.

6.4 Model Queue. Remote GUI

In tNavigator 4.2.1 Model Queue and Remote GUI module the following features are added:

- For LSF queuing system the number of nodes requested by the waiting tasks is displayed.
- Cluster calculations are not stopped when the queue that was created in tNavigator is closed.

6.5 Graphical User Interface

In tNavigator 4.2.1 Graphical User Interface the following features are added:

- The possibility to navigate quickly to the line in the model's file in which an error or warning occurred while reading. The transition is performed by double-clicking on the line with the message on the panel report.
- User Cut concept have been extended. The possibility to create a cut for grid blocks with specified map value is available.
- Visualization of parameters that are specified via the keywords ZMFVD and TEMPVD is available in Properties option.



- The possibility to build the vertical cross sections of the model by planes parallel to the XZ plane and YZ.
- The possibility to continue down the well trajectory in the Add well dialogue is available via Add Point button.
- Well's transmissibility factor can be edited in Wells Properties dialogue.
- Any graph for well and for group can be loaded to Graphs Templates using Load graphs button.

6.6 Licenses and License server

In tNavigator 4.2.1 the following features are added to work with license::

- The possibility to use a license server for Windows (without the virtual machine). Only the following systems are supported: 64-bit version of Windows 7, 8, 8.1, 10, Vista.

7 tNavigator 4.2.0

This version is released as tNavigator 4.2.0 due to significant improvements in the GUI and integration of simulator with the preprocessor. The Geology module was renamed as Model Designer due to the fact that at the moment the main it's application is creation of simulation models for tNavigator (preprocessor). All the functionality of Geology module is available in Model Designer now.

7.1 tNavigator kernel

In tNavigator 4.2.0 kernel new options are supported for the following model formats: E100, E300, STARS.

Calculations speed-up, accuracy settings:

- Speed-up of black oil and compositional models calculations using AIM method. For compositional models AIM is used by default.

For models in E100 and E300 format the following options are supported:

- Coal Bed Methane Model can be used (keywords COAL, COALNUM, DIFFCOAL, LANGMUIR, ROCKDEN, GASCONC, LANGMEXT, DIFFCBM, RESORB, GASSATC).
- Relative permeability of the injected phase can be defaulted (parameter 6 of the keyword COMPINJK).
- Minimum time interval between well priority calculations can be specified (parameter 1 of the keyword PRIORITY).
- The possibility to choose if the time steps are controlled to coincide exactly with the on/off cycling times of the well (parameter 6 of the keyword WCYCLE).
- Rescaling of saturations at wells connections can be used (keyword COMPRP).
- Segment number to allocate to all connections within the specified range can be set (parameter 11 of the keyword COMPSEGS, COMPSEGL).
- A segment of multi-segment well can be defined to represent a flow limiting valve (keyword WSEGFLIM).
- Low salinity option can be used: the oil and water RP and the water-oil capillary pressure are functions of the salt concentration (keywords LOWSALT, LSALTFNC, LWSLTNUM).
- The cubes can be imported to the global grid via the keyword IMPORT (option UNFORMATTED).

- Speed-up in opening models with a large number of local grid refinements (>10000).
- Well's connections can be specified via the keyword WELLCOMP (parameters 1-9, 11-12). This keyword is analogue of the keyword COMPDAT.
- Producer's control mode can be specified via the keyword WELLPROD (parameters 1-14). This keyword is analogue of the keyword WCONPROD.
- Group limits and targets can be specified via the keyword GRUPPROD (parameters 1-8). This keyword is analogue of the keyword GCONPROD.

For models in E100 format the following options are supported:

- Mixing of waters with different salinities BRINE can be used with ASP option (injection of polymer-alkaline-surfactant) (keywords SALTNODE, PLYVISCS).

For models in E300 format the following options are supported:

- An injection mixture by order can be specified (keyword WINJORD).
- The data to maintain the average pressure in a particular pressure maintenance region at a specified target can be specified (keyword GPMAINT3).
- Drainage option can be used in hysteresis (keyword DRAINAGE).
- Equation of state number can be specified for each separator stage (8-th parameter of FIELDSEP, 9-th parameter of FIPSEP, 10-th parameter of SEPCOND).
- An alternative model for capillary number calculations is supported in velocity dependent RP (5-th parameter of VELDEP).
- Forchheimer model for connection D-factor calculations is supported in velocity dependent RP (4-th parameter of VELDEP).
- Recovery plant table can be specified for compositional models (keyword RECOVERY).
- Minimal and maximal reservoir temperature can be specified for thermal models (keyword TRANGE).
- Numerical model for heat loss can be used in thermal models (option N in 6-th parameter of the keyword ROCKPROP).
- The molar composition of the injected fluid can be defined as a mixture (option MIX of the keyword WELLINJE).

For models in STARS format the following options are supported:

- Minimal and maximal reservoir temperature can be specified (keywords MINTEMP, MAXTEMP).

Special options:

- Maximum rate of increase of solution gas-oil ratio as a function of pressure can be specified (only in black-oil models) (keyword DRSDTVP).
- An alternative model of gas dissolution that takes into account the exponential nature of the system relaxation can be used (only in black-oil models) (keyword DRSDTVPE).
- Possibility to use Corey (LET) correlation only for RP and define capillary pressure via table (in this case one should enter 0 in parameter 12 (power) of the keyword COREYWO, COREYGO (LETWO, LETGO) and define tables SWOF, SGOF or other. Values for capillary pressure will be taken from tables and RP will be calculated using Corey (LET) correlation.
- Possibility to define EGRID for grid visualization (keyword VISGRID). This option is used for models with unstructured grids.

In MPI version:

- Hybrid models are supported (model in E100 or E300 format, well data in MORE format).

Input output data, Export Results:

- in SUMMARY section the following parameters can be used:
 1. output of fluids-in-place at surface (separator) conditions or reservoir conditions SFIP, RFIP (.UNRST-file);
 2. liquid and vapor mole fractions for wells, groups, field: FXMF, FYMF, FZMF, GXMF, GYMF, GZMF (.UNSMRY-file).

7.2 Model Designer

In tNavigator 4.2.0 the following features are added to Model Designer:

- Integration of the simulator with Model Designer.
- Option Definitions is available.
- The possibility to open additional windows with the functionality of the main window.
- The possibility to load well data (events and history) in schedule format.
- The detailed information of component grouping (lumping) for compositional models is available.
- Well filter is available.
- The possibility to create well groups.

- The possibility to add the following cubes:
 1. RP end-point scaling (swcr, sgcr, sower, sogcr, swu, sgu, swl, sgl, swlpc, kro, krw, krg, krwr, krgr, krorg, pcw, pcg);
 2. new fluid-in-place (FIP) regions FIPXXX;
 3. cubes to work with the pore volume (MINPVV, MULTPV).

7.3 Assisted History Matching

In tNavigator 4.2.0 Assisted History Matching module the following features are added:

- Integration with Model Designer: the possibility to create automatically basic variables (RP end-points specified via Corey correlation (COREYWO, COREYGO) and contact depths (EQUIL)).

7.4 Model Queue. Remote GUI

In tNavigator 4.2.0 Model Queue and Remote GUI module the following features are added:

- Queuing system SLURM is supported.
- Visualization of cluster queues load (output of the number of occupied nodes).
- The possibility to reassign job to another cluster queue (if the job has not started yet).
- The possibility to send jobs automatically to multiple cluster queues.
- The possibility to close tNavigator when the local queue is completed.

7.5 Graphical User Interface

In tNavigator 4.2.0 Graphical User Interface the following features are added:

- The possibility to hide some of the options.
- The possibility to choose the map visualization type: 3D, 2D, Histogram.
- The possibility to use the grid size up to 10x10 windows in Graphs Templates.
- In Load Well Data dialogue the column preview of selected files is available (for history and perforations).
- Visualization for multi-segment wells is available: segments structure in the form of a tree and graphs of total parameters for segments.
- For compositional models graphs are grouped by components, component injection graphs for wells and groups are available.

- The possibility to view and modify the parameters of the simulator's iteration process (keyword RUNCTRL) from the GUI in Document. Simulator options dialogue. Changes may be done in sections RUNSPEC (global settings) and SCHEDULE (settings for the individual time steps).

7.6 Licenses and License server

In tNavigator 4.2.0 the following features are added to work with license:

- The possibility to reinstall the license during the calculation in the GUI version.
- The possibility to use a new format of license: a hybrid license based on usb-device and file with the license information that allows to change the number and the duration time of license without changing the USB key, just changing the file.
- Simplified reference to the license can be used:
`http://<license>/tNavigator<group_id>` or `http://<license>/navigator<group_id>`, where <license> – ip-address of the license server or DNS-name, a <group_id> – number of license group.

In tNavigator 4.2.0 the license server can be administered using the web-interface:

- The license file can be loaded using the web-interface.
- Server log-file can be viewed using the web-interface.
- Web-interface is available via the simplified license references:
`http://<license>/tNavigator` or `http://<license>/navigator`, where <license> – ip-address of the license server or DNS-name.

8 **tNavigator 4.1.3**

8.1 **tNavigator kernel**

In tNavigator 4.1.3 kernel new options are supported for the following model formats: E100, E300, IMEX, STARS, MORE.

Calculations speed-up, accuracy settings:

- Speed-up in calculations of thermal models having a water zone (option WATERZONE in the keyword RUNCTRL is used for default for compositional and thermal models).
- The water molar concentration in water zone can be excluded for compositional models if WATERZONE option is used (is used by default).
- The possibility to switch on/off WATERZONE option in the SCHEDULE section via the keyword RUNCTRL.
- The main variable (the last hydrocarbon component) can be excluded for thermal models via the option INCVCE 0 in the keyword RUNCTRL (is used by default).

For models in E100 and E300 format the following options are supported:

- Well friction can be taken into account in the well bore (keywords WFRICTN, WFRICTNL, WFRICSEG, WFRICSGL).
- The method (implicit or explicit) of VFP table interpolation for the well can be chosen (2-nd parameter of the keyword WVFPEXP).
- The minimum group potential rates for a new drilling can be specified (GDRILPOT).
- Minimum and maximum permitted sales gas production rate can be specified (parameter 3-5 of the keyword GCONSALE).
- The possibility to stop the run at the next report time step in case if the well is shut or stopped for any reason after being opened (parameter 8 of the keyword WECON).
- The fixed pressure drops between network node and well's THP can be specified (WNETDP).
- Grid block permeabilities can be averaged when the interblock transmissibilities are calculated (PERMAVE).
- Block center method can be used in transmissibility calculations (OLDTRAN).
- The depths of the middle of each grid block can be specified (MIDS).
- The surface tension can be defined as a function of pressure (STVP) for the MISCIBLE option.

For models in E300 format the following options are supported:

- Water wet hysteresis models are supported (Jargon model) (values 8 and 9 in the 2-nd parameter of the keyword EHYSTR).
- WAG hysteresis model can be used (parameters 1-3, 5-8 of the keyword WAGHYSTR).

For models in MORE format the following options are supported:

- Lower watercut, gas-oil ratio and other lower limits can be used for wells (PLIM).

For models in STARS format the following options are supported:

- Heater wells can be specified (HTWELL, HTWRATE, HTWRATEPL, HTWTEMP, HTWI).
- The reaction rate temperature-dependence factor with multiple activation energy values can be specified (EACT_TAB).

For models in IMEX and STARS format the following options are supported:

- Fracture volume fraction and the rock-in-fracture fraction can be specified for dual porosity models (FRFRAC, FORMINFRAC).
- The multipliers for geometric grid block volume can be specified (VOLMOD).

In MPI version:

- The hydraulic fractures can be specified using the keyword COMPFRAC.
- Models with geometry DX/DY/DZ can be used.

Special options:

- LET correlation can be used for relative permeabilities in E100 and E300 format models (keywords LETWO, LETGO)
- The length of perforated interval can be set in specified grid block in E100 and E300 format models (COMPVAL).
- Lower economic limits can be set for watercut, gas-oil ration, water-gas ratio and gas-liquid ratio in E100 and E300 format models (negative values should be specified in the keyword WECON parameters 4-6, 13).

Input output data, Export Results:

- in SUMMARY section the following parameters can be used:
 1. inter-region phase flow total (ROFT, RGFT, RWFT);
 2. salt, polymer, alkaline and other tracer concentrations (WTIC, WTPC, WTIR, WTPR, WTIT, WTPT, WCIC, WSIC, WTICALK, WTICSUR);
 3. data for well segments (SOFR, SGFR, SWFR, SPR, SPRD, SPRDH, SPRDF, SPRDA, SWFV, SOFV, SGFV, SWHF, SOHF, SGHF, SLPR, SWCT, SGOR, SOGR, SGWR, SWGR, SOWR, SWOR, SLGR, SGLR).

8.2 Geology

In tNavigator 4.1.3 the following features are added to Geology module:

- the possibility to load grids, faults and wells from rescue files;
- dual porosity support;
- calculations of resources for black oil models;
- the possibility to load PVT and RP data in E100 syntax;
- the possibility to load well data in SCHEDULE format;
- the possibility to load component properties for compositional models in E300 syntax;
- component grouping (lumping) for compositional models;
- maps visualization on Well Section;
- the possibility to edit fault transmissibility in GUI;
- 2D map visualization;
- possibility to run simulation model directly from Geology without opening it in separate window in tNavigator, with maps and graphs available in Geology;
- visualization of contour lines on 2D maps;
- Statistics button for 2D maps;
- the possibility to measure distances on 2D and 3D maps;
- the possibility to create and edit sections;
- streamlines visualization.

8.3 Assisted History Matching

In tNavigator 4.1.3 Assisted History Matching module the following features are added:

- the possibility to use RFT data in history matching;
- the possibility to normalize objective function by object (wells, groups) number and parameter (rates, totals, pressure) number;
- calculation of P10-P50-P90 and any other P-quantiles for parameters that are selected by user;
- the possibility to merge several history matching projects, created for the same model with the same set of variables but with different calculated experiments.

8.4 Graphical User Interface

In tNavigator 4.1.3 Graphical User Interface the following features are added:

- visualization of LET correlation data for relative permeabilities;
- new interface for visualization of Corey correlation (RP) and Standing correlation (PVT);
- the possibility to cancel the last action in Map Editing (Ctrl+Z);
- visualization of resources maps for compositional models;
- visualization of resources calculation progress;
- visualization of VFP tables;
- visualization of hysteresis;
- the possibility to import several User Maps simultaneously;
- visualization of component number in Information option;
- visualization of graphs for well segments;
- new arithmetic functions for maps are available in User Maps and User Graphs: column operations (min_2d (minimum), max_2d (maximum), avg_2d (average), sum_2d (sum));
- in Graph Templates:
 1. the possibility to visualize graphs for months and years;
 2. the possibility to select the range (for time steps) of graph visualization.

8.5 Licenses and License server

In tNavigator 4.1.3 the following features are added:

- visualization of the license server status and usb-key data in the "License details".

9 tNavigator 4.1.2

9.1 tNavigator kernel

In tNavigator 4.1.2 kernel new options are supported for the following model formats: E100, E300, IMEX, STARS, MORE.

Calculations speed-up, accuracy settings:

- Speed-up of compositional models calculations. For black oil and compositional models AIM option is supported (beta version).
By default the fully implicit method is used; the adaptive implicit method may be included as an option AIM of the keyword RUNCTRL.
- Speed-up in calculations of models having a water zone (water saturation in the grid block is equal to 1). The option can be included as WATERZONE in the keyword RUNCTRL (is used by default for compositional models).

For models in E100 and E300 format the following options are supported:

- The well can be closed during drilling and workovers in case of automatic drilling of new wells. It will be opened in a specified number of days taken to drill it (parameter 3 of the keyword WDRILTIM).
- The iteration parameters for multi-segment wells can be specified (parameter 1 of the keyword WSEGITER).
- The well can be opened if it was closed because of GROUP or FIELD limits violation (option G in the keyword WTEST).
- The number of FIP region can be specified, that will be used in the calculations of the well rate in reservoir conditions (parameter 13 of the keyword WELSPECS).
- Well rate can be controlled by the gas-oil ratio (keyword WGORPEN).
- The well startup time and maximum timestep length, at which the well is turned on by automatic cycling (parameters 4 and 5 of the keyword WCYCLE).
- Maximum number of wells on artificial lift (ALQ) in the group can be specified (parameter 3 of the keyword GLIFTLIM).
- Parameters for reinjection or voidage replacement can be specified (parameters 7-8 of the keyword WCONINJ).
- The dynamic changing of fixed pressures can be used (keyword GNETDP).
- In the keywords OPERATE, OPERATER operations ABS, MULTIPLY can be used.

- In the keyword **OPTIONS** the 117-th option can be used:
 - Value 1** – the map **MULTNUM** should be specified both for matrix and fracture;
 - Value >= 2** – maps **MULTNUM**, **FLUXNUM**, **PINCHNUM**, **OPERNUM** should be specified both for matrix and fracture.
- If **NTG** is used in the arithmetic (**ADD**, **MULTIPLY**, ...) non-specified values are replaced by 1.

For models in E300 format the following options are supported:

- The availability of injection fluids can be taken into account in injection rate calculations (keyword **WAVAILIM**).
- Economic limits for production wells can be specified for component mole fractions (keyword **WECONCMF**).
- For compositional models hysteresis of **RP** and capillary pressures can be used with the option **MISCIBLE**.
- The makeup gas can be used for injection (parameter 4 of the keywords **WINJGAS** and **GINJGAS**).
- Modifications of the map **MULTPV** in **EDIT** section via arithmetic (**ADD**, **MULTIPLY**, ...) is ignored to reproduce the behavior of **E300**.

For models in E100 format the following options are supported:

- For multisegment wells the segment external source or sink can be specified (keyword **WSEGEXSS**).
- Sales gas production rate target can be specified for groups (parameters 1 and 2 of the keyword **GCONSALE**).

For models in MORE format the following options are supported:

- Parameters for reinjection or voidage replacement can be specified: **GVRT**, **GWRT**, **GGRT**, **VREP**, **RECYcle**.

For models in STARS format the following options are supported:

- The option **SEGREGATED** can be used to calculate phase resources and phase rates in surface conditions (keyword **SURFLASH**)
- The bubble point pressure at initial temperature at each block for specified component can be specified (keyword **PBC**).
- The following models are supported: Linear Elastic, Nonlinear Elastic, Dilation-Recompaction (keywords **PORMAX**, **CPORPD**, **PBASE**, **PRPOR**, **POR**, **CPEPAC**, **PDILA**, **CRD**, **PORRATMAX**, **PPACT**, **FR**).

For models in IMEX and STARS format the following options are supported:

- Fracture blocks of global grid can be deactivated if any one of the following conditions is satisfied:
DIFRAC = DJFRAC = DKFRAC = 0
PINCHOUTARRAY = 0
PERMI = PERMJ = PERMK = 0

In MPI version:

- The possibility of streamlines calculation is added.
- The keyword MINP (Minimal Pore Volume Tolerance) is supported for MORE format models.
- Full support of the keyword COPYBOX. Input and output BOXes can be used with different Z-coordinates.

Special options:

- For models in format E100 and E300 economic limits can be specified in user-defined way for wells (WECONX) and for groups (GECONX), also UDQ can be used.
- The following options of the keyword TNAVCTRL are added:
DPGRID_PRE2014 > 0 – switch off the copying of NTG values from matrix to fracture blocks (if the values are not specified) in dual porosity models for E300 format;
SWCR_CORR: 1, 2 or 3 – adjustment of SWCR in blocks using SWU, SWL.
- The special permeability value used for JFUNC computation can be specified for E100 and E300 format models (the keyword JFPERM). If this value is specified for block, than the 6-th parameter of JFUNC (JFUNCR) is ignored).

9.2 Geology

In tNavigator 4.1.2 the following features are added to Geology module:

- operations with maps and horizons: rotation and movement;
- the possibility to load horizons in binary format (GRDB);
- the possibility to create horizons via point set;
- the possibility to construct Vertical Proportional Curves for cubes;
- histograms;
- the possibility to create a grid with unstructured faults.

9.3 Assisted History Matching

In tNavigator 4.1.2 Assisted History Matching module the following features are added:

- calculation of P10-P50-P90 for parameters that are selected by user;
- the possibility to set the periods of recorded map and graph data when the job is added to queue.

9.4 Graphical User Interface

In tNavigator 4.1.2 Graphical User Interface the following features are added:

- the possibility to load RFT pressures, automatic calculation of corresponding reservoir pressure;
- visualizations of graphs for surface network (if the keyword NETWORK is used);
- visualizations of graphs for SEMI-ANALYTICAL aquifers;
- visualizations of Drainage Network on 2D maps (connection between producers and injectors);
- the possibility to fill contour lines with different colors (2D maps);
- In Graph Templates:
 1. visualization of user-defined UDQ;
 2. the possibility to sum graphs for components;
 3. the possibility to rename the axis.

9.5 Compatibility with previous versions

Extended possibilities of calculation results storage. To view the calculations results of version 4.1.2 use only the GUI version 4.1.2.

9.6 License server

In tNavigator 4.1.2 licence server:

- The support of systemd for RHEL 7 compatible with Linux-distributive is added.
- The support of Apache 2.3/2.4 is added.
- The possibility to reserve licenses for cluster version with the utility tNavigator License Status is added.
- Settings for automatic rotation of server logs are added.

- All kinds of statistics take into account the setting of output IP/Hostname.
- Exterior JavaScript libraries (jQuery and plug-ins) that are used in the web-interface have been updated.

10 tNavigator 4.1.1

10.1 tNavigator kernel

In tNavigator 4.1.1 kernel new options are supported for the following model formats: E100, E300, IMEX, STARS.

For models in E100 and E300 format the following options are supported:

- Maximum gas-liquid ratio (GLR) can be specified as an economic limit (parameter 13 of the keyword WECON).
- The guide rate can be set at the beginning of each timestep equal to the group's net voidage rate (net voidage rate is equal to the voidage production rate minus the reservoir volume injection rate of any other phases) – option NETV of the keyword GCONINJE (parameter 10).
- Maximum rate of change of guide rate for wells under group control can be specified (the keyword DGRDT).
- A group can be set whose rate target the automatic choke attempts to match by adjusting the pressure drop across it (parameter 5 of the keyword NODEPROP).
- The well can be closed if it is found to be operating on the stabilized part of its VFP curve (parameter 3 of the keyword WVFPEXP).
- Voidage mobility for injectors can be set (keywords COMPMOBI, COMPMBIL).
- Well priority numbers can be set for the wells under group control (keyword WELPRI).
- A segment of multi-segment well that represents a sub-critical valve can be defined (keyword WSEGVALV).
- Pore volume multipliers (MULTPV) can be used in SCHEDULE section.

For models in E300 format the following options are supported:

- Advance import gas can be assigned to a group supplying gas for reinjection (keyword GADVANCE).
- Mixture injection can be used (keyword WINJMIX and MIX option of the keywords WINJGAS, GINJGAS).
- WAG (water and gas) cycle types can be used: M – months and Y – years in the keyword WELLWAG.
- Pressure maintenance regions can be specified (keyword PMANUM).

- The availability of injection fluids can be taken into account when calculating injection rates (keyword WAVAILIM).

For models in E100 format the following options are supported:

- Maximum rate of increase of vapor oil-gas ratio (OGR) can be set (keyword DRVDT).

For models in STARS format the following options are supported:

- Initial distribution can be set from the conditions of hydrostatic equilibrium (VERTICAL) in conjunction with initial phase saturations (SW, SO, SG).
- Default parameter values are supported for analytical aquifers (AQPROP).
- Default parameter values are supported for injection enthalpy calculations.
- The SEMI-ANALYTICAL aquifer model can be used.
- Multiple viscosity regions can be set (keywords VISCTYPE, VSTYPE).
- Multiplies for a well operating targets or limits can be used (keyword WTMULT).

For models in IMEX, STARS format the following options are supported:

- Unweighted injectors. Injected fluid mobility should be part of a well index (keyword *UNWEIGHTED INJECTOR).

Input output data, Export Results

- Multout mode is supported for export results in Eclipse format.
- The size of file with calculated maps has been optimized.
- Parameter ALLPROPS of the keyword RPTRST is supported.

10.2 Geology

In tNavigator 4.1.1 the following features are added to Geology module:

- Discrete interpolation in arithmetic is available.
- New objects are available: a point set and multi-valued horizons. For them the following features are supported:
 1. The point set can be loaded from a text file.
 2. The point set can be created via horizons.
- New tools can be used to navigate through operations with objects.
- A new object "selector" is available for the convenience of working with the well section.

- A step-by-step update of calculated objects has been implemented that is convenient for long calculations: horizon interpolation and automatic markers correlation.
- A creation of new objects from the object tree is available.
- The calculation cancellation can be used.
- The area of grid editing can be calculated via a single point with a radius.
- Construction of geological grid with faults:
 1. An algorithm to "pull" grid lines to the fault has been optimized: the method of "dual" grid.
 2. An integration of faults of arbitrary shape, which don't violate a system of generators of the grid, has been implemented. The method of "draft-horizon" is used. The establishment of correspondence between the connected components is used for fault intersections with core horizon and horizons of each connected component.
- Tools for working with faults:
 1. A group of faults can be built with the addition of structural and non-structural faults.
 2. Faults can be limited in height.
 3. Faults can be constructed from the set of points or from the several surfaces.
 4. Automatic processing of faults intersection is available.
- Horizons interpolation by markers or point sets, taking into account the faults of arbitrary shape, is available.

10.3 Assisted History Matching

In tNavigator 4.1.1 Assisted History Matching module the following features were added:

- the ability to specify manually the values of the variables;
- the ability to remove the experiment;
- the log-normal distribution of parameter.

10.4 Remote GUI

In tNavigator 4.1.1 Remote GUI module the following features were added:

- the possibility to run different versions of tNavigator from GUI;
- the possibility to do forced-ending of dangling tasks;
- the messages on the log panel are sorted by their type.

10.5 Graphical User Interface

In tNavigator 4.1.1 Graphical User Interface the following features are added:

- Axis are available in the compositional calculator.
- Visualization of the time of flight of fluid particle on streamlines on 2D and 3D maps (uncheck "Show mesh" to see the streamlines).
- In Graphs Templates:
 1. The possibility to synchronize time axes is available;
 2. The possibility to create a screen shot is available;
 3. The possibility to print to the printer is available;
 4. The possibility to save in the vector format is available;
 5. Automatic check for not saved template is performed.
- In Create Forecast dialogue:
 1. The possibility to set THP control mode for producers is available;
 2. The possibility to set Drawdown control mode for producers is available;
 3. The possibility to set different control modes for water and gas injectors is available.
- In Well properties dialogue:
 1. The possibility to set Drawdown control mode for producers is available;
 2. Maximum gas-liquid ratio can be set as economic limit.
- Well trajectories can be loaded (Load Well Data dialogue) in the units different from the model units.
- Drawdown graph is visualized.
- The current connection status (open, closed, not specified) is visualized.
- Virtual connections created via hydraulic fracture are visualized in the connection list.
- The thickness of the contour lines and the size of the text can be set.
- In the mode "View Large Model":
 1. The possibility to see Initial maps is available;
 2. User Cuts are available;
 3. Well filters are available;
 4. Automatic model coarsening is done for viewing speed-up.

10.6 Compatibility with previous versions

Support for 32-bit Linux systems is no longer available (including the license server).

10.7 License server

In tNavigator 4.1.1 license server:

- Only 64-bit Linux-systems are supported.
- tNavigator versions below 4.0 are no longer supported.
- A new format of licenses is available: a hybrid license based on usb-devices and file with the license information that allows to change the number and the duration time of licenses without changing the USB key, just changing the file.
- For hybrid license a "hot-swap" of file with the license information is available.
- A fault-tolerance has been improved: tNavigator access keys are provided for 24 hours in case of errors in interaction with usb-device (assuming the smooth operation for 48 hours before the error).
- E-mail notifications of the licencing-period termination or of error interaction with the usb-device can be configured.
- A page with information about the version of the server and the connected usb license device is available.
- The basic Apache authentication has been supported, which allows to set the input username and password for access to the license server.
- On the page with the licenses that are currently being used, information about tNavigator versions is available.
- In the log files the time periods have been added.
- The spaces in the module names in the files of Open IT Statistics have been removed.

11 tNavigator 4.1.0

11.1 tNavigator kernel

In tNavigator 4.1.0 kernel compositional thermal models in STARS format are supported. New options are supported for formats: IMEX, E100 and E300.

For models in STARS format the following options were supported:

- K-values for hydrocarbon components in the GAS-OIL system can be set via tables (keywords GASLIQKV, KVTABLIM, KVTABLE) or via five coefficients in the correlation formula (keywords KV1, KV2, KV3, KV4, KV5). Optional specification of K-values for hydrocarbon component for calculating phase equilibrium in surface conditions (K_SURF) is available. For water component the internal correlation is used to calculate the equilibrium in the GAS-WATER system.
- Liquid phases individual component densities (in WATER, OIL) can be set as a functions of pressure and temperature (keywords MOLDEN, MASSDEN, MOLVOL, CP, CT1, CT2, CPT). The inner correlation formula is used if for water component if all parameters specified via the keywords MOLDEN/MOLVOL CP, CT1, CT2, CPT, are zero. Gas Z-factor is used to calculate GAS phase density. This factor is calculated from the cubic Redlich-Kwong equation of state with zero Binary interaction coefficients. The re-calculation of gas Z-factor is done at each Newton iteration (GASD-ZCOEF (IMPLICIT)). The densities of the individual solid components are set as functions of pressure and temperature (SOLID_DEN).
- Liquid phases individual component viscosities (in WATER, OIL) can be set as functions of temperature (or temperature and pressure) via the tables (keywords VISCTABLE, ATPRES), or via the correlation formula (AVISC, BVISC). The option of non-linear mixing is supported for OIL viscosity (keywords VSMIXCOMP, VSMIXENDP, VSMIXFUNC). Component individual viscosities in the GAS phase can be set via the correlation formula (AVG, BVG).
- Enthalpies of hydrocarbon components in the OIL and GAS phases can be set as functions of temperature (keywords CPG1, CPG2, CPG3, CPG4, CPL1, CPL2, CPL3, CPL4, HVAPR). The possibility to set the enthalpy of vaporization for the hydrocarbon components as a function of temperature (HVR, EV). The internal tables are used to calculate the enthalpy of the water component in the GAS and WATER phases, in this case the enthalpies of the water component are the functions of both temperature and pressure. The enthalpies of solid components in the solid phase can be set as functions of temperature (SOLID_CP). The rock enthalpy can be set as a function of temperature (ROCKCP).
- The SIMPLE model of thermal conductivity has been added (THCONMIX), which allows to take into account thermal conductivity of the mobile phases (THCONW,

THCONO, THCONG), the thermal conductivity of the solid phase (THCONS), and the rock conductivity (THCONR).

- Porosity dependence on temperature and pressure can be defined (keywords PRPOR, CPOR, CTPOR, CPTPOR).
- The analytical model of heat loss between the reservoir and surroundings is now available (keywords HLOSSPROP, HLOSST, HLOSSTDIFF).
- Fetkovich and Carter-Tracy aquifers are supported (keywords AQUIFER, AQMETHOD, AQPROP, AQLEAK).
- Two heater models are supported in Heater simulation: Heater with constant energy injection rate and Heater with energy injection rate that depends on temperature difference between the block and the heater (keywords HEATR, TMPSET, UHTR).
- Chemical reactions simulation is now available (keywords EACT, O2PP, STOREAC, STOPROD, FREQFAC, FREQFACP, RENTH, RPHASE, RORDER, RTEMUPR, RTEMLOWR, RXCRITCON).
- Initial conditions: initial conditions can be either calculated from hydrostatic equilibrium conditions or set explicitly (keywords PRES, TEMP, SW, SO, SG, MFRAC_OIL, MFRAC_GAS).
- It is possible to define different thermal primary variables of the filtration problem (energy density or temperature) (TFORM (ZH | ZT)).
- Dual porosity/dual permeability models have been added (keywords DUALPOR, DUALPERM).

For models in E300 format the following options are supported:

- Heater simulation: Heater with constant energy injection rate, Heater with energy density dependent injection rate and Heater with energy injection rate that depends on temperature difference between the block and the heater (HEATER).
- Matrix to fracture thermal conductivity for dual porosity models can be set explicitly (THCONMF).
- Liquid and solid phases thermal conductivities can be defined now (THCROCK, THCOIL, THCGAS, THCWATER, THCSOLID).
- The logics of single-porosity regions support in dual porosity models has been changed (keyword DPNUM). In single porosity blocks the data specified for matrix blocks is used.
- Wet gas rate limit is now available (parameter WGRA in the keywords GCONPROD, GCONPRI, GRUPTARG).

- The stage of the separator which defines the fluid composition and limit for injection can be set (5-th parameter of GINJGAS).
- The order in which fuel, sales and re-injection gas are taken from production gas steam can be provided now (WTAKEGAS).
- Molecular diffusion option has been added (keywords DIFFUSE, DIFFCGAS, DIFFCOIL).
- The coefficients for LBC correlation and reference surface tension in MISCIBLE option now can be set for each region (LBCCOEFR, MISCSTRR).
- Velocity dependent relative permeabilities have been added (keywords VELDEP, VDKRO, VDKRO).
- The supply of advance import gas can be assigned to a group that provides gas for re-injection (GADVANCE).

For models in E100 and E300 format the following options are supported:

- Injection network is now available (GNETINJE) as well as convergence parameters specification for network option (parameters 2-4 of the keyword NETBALAN);
- Gas Field Model. The calculation of the gas Daily Contracted Quantity has been added (DCQ): keywords DCQDEFN, GASBEGIN, GASEND, GASFIELD, GASMOUTH, GASPERIO, GASYEAR, GDCQ, GDCQECON, GSWINGF, SWINGFAC;
- Killough's Hysteresis Model used for the non-wetting gas and water phases and the wetting oil phase is now available (value 7 in the 2-nd parameter of the keyword EHISTR);
- The reading of CORNERS format grid geometry from the GRID file is improved for the case when inactive block data is absent;
- The compatibility for the names of groups and wells is improved (the first 8 significant characters are supported).

For models in MORE format the following options are supported:

- keywords X-DI, Y-DI, TUBI, LONG and PACK formats (VFPPROD);
- improvement of FIELD units support.

In MPI version:

- loading giant models: requirements for RAM are reduced;
- models in IMEX and STARS formats can be calculated in MPI version.

11.2 Geology

In tNavigator 4.1.0 the following features are added to Geology module kernel:

- construction of three-dimensional geological grids with faults (the faults, specified via ruled surfaces, are supported);
- automatic correlation of well data (selection of markers from curves), a simple option;
- faulted model export: the keywords THPRES, FAULTS, MULTFLT, THPRESFT;
- in the BLOCK function in arithmetic the dual porosity is supported;
- option of discrete cubes interpolation;
- option of loading cubes.

In tNavigator 4.1.0 the following features are added to Geology module GUI:

- acceleration of 2d-maps visualization;
- dual porosity model manual 3d-map editing (GUI);
- the 3d-visualization of connections that are specified on trajectories (without considering the time).

11.3 Assisted History Matching

In tNavigator 4.1.0 Assisted History Matching module the following features were added:

- parallel run of multiple versions of the differential evolution algorithm;
- a quick comparison of several similar models without adding variables to the model;
- loading history of average reservoir pressure;
- the possibility to use arithmetic expressions with variables instead of variables in MORE models (and in hybrid models in the RECU section);
- analysis for any set of parameters;
- the possibility to use the constants e and π to set variable value and limits.

For model queue the following features were added:

- an external API is made to run the simulator;
- the possibility of limiting the number of tasks on the cluster;
- saving of job queues to files that can be transferred between computers;
- view log of model calculation (monitor job) after completing the task in a normal queue (similarly, as Show Log in Remote GUI manager);
- the possibility to limit task calculation time in the queue.

11.4 Graphical User Interface

In tNavigator 4.1.0 Graphical User Interface the following features were added:

- The compositional calculator that provides the phase analysis of fluids, allows to find bubble point pressure and the dew points pressure.
- Graph Templates:
 1. The graph may be pinned (the pinned graph doesn't change when the selected objects are changed).
 2. It's possible to distribute different objects graphs automatically to different panels.
 3. The undo option (Ctrl+Z)
 4. Graphs Templates Options dialogue is improved (You can edit the settings of all graphs and template settings in one dialog.)
 5. Well lists are available in templates.
 6. Sum and average are available for graphs of various objects.
 7. It's possible to set the difference with the base model (Right mouse click on the model name and select "Set as reference model").
 8. Search option for objects, graphs and templates is improved (search now finds everything that contains as substring all words typed by the user).
 9. Possibility to reorder templates by dragging them with the mouse.
 10. Back lighting of current panel graph names during editing.
 11. The support of compositional models is improved (the list of components and separator stages is added).
 12. The parameter list can be displayed as a tree for quick search when editing.
- GUI:
 1. Each model is run in a separate process to increase the stability in case of the emergency termination of one of the calculation processes.
 2. The Log panel is improved (the possibility to hide the Log panel and to display information about the number of messages in different categories).
 3. Export of the well trajectories to a file via the keyword WELLTRACK (columns: X, Y, Z, Measured Depth) on the "Well Profile".
 4. An option "Draw Trajectories Projections" is added on 2d maps. If you choose this option the well trajectory projection to the selected map will be shown (if the trajectory is set).
 5. The well efficiency factor can be edited in "Well properties" dialogue (Economic Limits tab).

6. In "Load Well Data" option the possibility to upload files with a hierarchy of well groups is supported. Reload the model to apply the changes.
- Large models. For models, calculated on a cluster with full results export, it is possible to see 3D maps on computers with limited RAM. Open the model via "View Large Model" option (in the main tNavigator window). Features:
 1. Visualization of cubes exported using the keyword RPTRST.
 2. Visualization of wells: the current status is shown.
 3. Visualization of streamlines exported using an option of the command line `-ecl-sln`.
 4. Possibility to show I, J, K sections.
 5. Loading data progress bar.

11.5 Compatibility with previous versions

It's impossible to create a forecast in the current version 4.1.0 for models with hydraulic fractures (keywords WFRACP, COMPFRAC) if the calculation of base model was made in the previous version 4.0.4 or earlier. For correct results, please recalculate the base model in 4.1.0.

12 **tNavigator 4.0.4**

12.1 **tNavigator kernel**

In tNavigator 4.0.4 kernel the following options are supported:

1. For models in E100 and E300 format alkaline injection is supported. The following keywords can be used: ALKALINE, ALKADS, ALSURFAD, ALPOLADS, ALSURFST, WALKALIN.
2. For models in E100 and E300 format surfactant injection is supported. The following keywords can be used: SURFACT, SURF, SURFADS, SURFROCK, SURFST, SURFCAPD, SURFVISC, WSURFACT.
3. For models in E100 and E300 format polymer injection is supported. The following keywords can be used: POLYMER, SPOLY, PLYADS, PLYROCK, PLYVISC, PLYMAX, PLMIXPAR, PLYSHEAR, WPOLYMER.
4. For models in E100 and E300 the following options are supported
 - an option TRANPORV of the keyword PETOPTS;
 - operations CON, CON+, WELL for group productions limits in the keywords GCONPROD, GCONPRI;
 - the keyword WELLOPEN;
 - the keyword COMPLMPL;
 - well limits on bottom hole gas liquid ratio (keyword WBHGLR);
 - group reservoir volume injection rate control mode (keyword GCONINJE, parameter RESV);
 - specification of well PVT region (11-th parameter of the keyword WELSPECS);
 - calorific rate limit and natural gas liquid limit (NGL and CVAL) – parameters 18 and 20 of WCONPROD, parameter 12 of WCONHIST, WELTARG NGL, WELTARG CVAL;
 - recording of *.end-file, which contains the number of all errors/problems/warnings in the model;
 - editing of ROCKV keyword in EDIT section via arithmetic operations;
 - the keyword MULTREGT in dual porosity models.
5. In MPI version the following options are supported:
 - the keyword WCONINJP;
 - the keyword GRUPNET;
 - usage of maps MULTNUM, FLUXNUM, OPERNUM from previous sections in arithmetic operations.

12.2 Geology

In tNavigator 4.0.4 the following features are added to Geology module kernel:

- option of preparatory curve interpolation in multi-layer interpolation;
- 3D interpolation;
- calculations of Voronoi regions with radius specification (multi-layer and 3D);
- calculation of Cut (cube with values 0 and 1) according to well trajectories with radius specification;
- calculation of Cut (cube with values 0 and 1) according to well perforations with radius specification;
- calculation of SATNUM regions according to well data;
- calculation of connected components (via ACTNUM);
- export of "USER files" for GRID section
- possibility to create a geological project "tied" to existing hydrodynamic model; after objects editing the changes are saved in "USER files";
- function "block" for GRID section (in user arithmetic);
- the possibility to remove the calculation form the list in WORKFLOW.

In tNavigator 4.0.4 the following features are added to Geology module GUI:

- units visualization;
- optimization of maps and horizons visualization on 2D;
- an option "show mesh" for maps and horizons;
- smoothing option for contour lines;
- rulers with scale in 2D;
- a possibility to align the wells according to markers and depth on Well Section;
- an option to create and edit markers on Well Section; undo option;
- navigation buttons on 3D: a top view, side, bottom, etc.;
- translucency option for horizons on 3D;
- filters for 3D-meshes (I,J,K - filter and Cube Value Filter);
- a possibility to see the change of parameters for interactive 2D mesh modification;
- interactive cube editing in 3D (a brush);
- information windows with statistics for some objects.

12.3 Assisted History Matching

In tNavigator 4.0.4 Assisted History Matching module the following features are added:

- Automatic conversion of relative permeabilities tables SWFN, SGFN and SOF3 to Corey correlation (at user selection in GUI).

12.4 Remote GUI

In tNavigator 4.0.4 Remote Graphical User Interface the following features are added:

- An option to see only the results on graphs without loading all model results.

12.5 Graphical User Interface

In tNavigator 4.0.4 Graphical User Interface the following features are added:

- User-customizable Graph Templates that allow:
 - to make a quick selection of a set of graphs on the screen;
 - to adjust color, thickness, and the names of the graph icons;
 - to configure the type and color of the fonts;
 - to configure the captions and units for graphs;
 - to show several sets of graphs in one window;
 - to export and import Graph Templates from the file.
- The possibility to compare graphs of any two models results (from all graphs loaded) in the "Hist. vs Calc."Graph tab, and a more convenient menu.
- The possibility to use unique streamlines colors for different wells.
- Quick selection of displayed grid blocks on 3D map (selection of X, Y, Z layer numbers).
- An option to load only graphs from model results without loading maps.

13 **tNavigator 4.0.3**

13.1 **tNavigator kernel**

In tNavigator 4.0.3 kernel the following options are supported:

1. For thermal compositional models in E300 format:
 - New Well control mode – Control by total molar rate target (parameter 14 of the keyword WCONPROD).
 - New Well control mode – Control by wet gas rate target (parameter 13 of the keyword WCONPROD, parameter 11 of WCONHIST, option WGRA of the keyword WELTARG).
 - Calculation of friction for multisegment wells via correlation formulas (corresponding parameters of keywords WELSEGS, COMPSEGS).
2. For thermal models in E300 format:
 - New Well control mode – Control by steam rate target (parameter 15 of the keyword WCONPROD, option STRA of the keyword WELTARG).
 - Steam production rate limit for producers (parameter 15 of the keyword WCONPROD).
 - Multicomponent gas injection.
3. For E100 format models the following options are supported:
 - Calculation of friction for multisegment wells via correlation formulas (corresponding parameters of keywords WELSEGS, COMPSEGS).
 - Special formulas of inflow of gas from the completed grid blocks and the well completions: R-G, P-P, GPP (parameter 8 of the keyword WELSPECS).
 - Output of streamlines to binary files SLNSPEC, SLNxxxx (option `-ecl-sln` (for console version) or from graphical interface).
 - Secondary water cut limit for wells (parameters 11–12 of the keyword WECON).
 - Switch off automatic compressors (the keyword COMPOFF).
 - Removing and moving the wells in the well lists (keyword WLIST, operations DEL and MOVE).
 - ALQ specification in the keywords WCONHIST and WCONPROD.
 - Specification of dependence of relative permeabilities end-points from temperature (keywords ENPTVT, ENKRVT, ENPCVT).
4. For MORE format models the following options are supported:
 - Direct calculation in MPI version (without intermediate data conversion).

- Recalculation of well bottom hole pressure at equivalent radius (keywords and events PREX, P-RE).

5. In MPI version the following options are supported:

- MORE-format models.
- Calculation of flows FLOWW, FLOWO, FLOWG, FLOWWZ, FLOWOZ, FLOWGZ.
- Usage of COPYBOX in case in the copied blocks are equal.
- For GDFILE an amount of required RAM is reduced.

13.2 Geology

In tNavigator 4.0.3 Geology module the following features are added:

- Local interactive editing of 3D mesh.
- Local interactive editing of horizons.
- Local interpolation of cubes.
- Contour lines visualization for maps and horizons.
- Creation and editing of objects for PVT, RP, equilibrium.
- Creation of maps with Voronoi regions via markers.
- New arithmetic functions: INTERPOLATE_ML_TRIVIAL, INTERPOLATE_ML_IDW, INTERPOLATE_ML_SGS, INTERPOLATE_ML_KRIGING.
- Logs visualization with cylinders in 3D.
- Creation and editing of palettes.
- Well section was improved.
- Geological project can be created form hydrodynamic model. The following functions were added:
 - Loading of Inactive blocks.
 - Loading of regions FIPNUM, SATNUM, EQLNUM, PVTNUM, ACTNUM.
 - Loading of PVT, RP, equilibrium.

13.3 Assisted History Matching

In tNavigator 4.0.3 Assisted History Matching module the following features are added:

- Automatic conversion of RP tables to Corey correlation (from GUI).
- Forecast objective function.
- An option to match BHP, THP and reservoir pressure.
- An option to load in history matching project models from another project.

Model queue was improved (calculations are started in separate processes, files backup on timer was added).

13.4 Remote GUI

In tNavigator 4.0.3 Remote Graphical User Interface the following features are added:

- Queue type can be specified in installation time. The following options are supported:
 - LSF
 - PBS/torque
 - SGE (Sun Grid Engine)
- Old versions of PBS/torque are supported (below 2.3).

13.5 Graphical User Interface

In tNavigator 4.0.3 Graphical User Interface the following features are added:

- Export of gas field development data in tabular form.
- Support of FIPOWG keyword (E100/E300 - data format) in viewing results mode.
- An option to save and load model visualization settings templates (graph colors etc.).
- An option to use different colors instead of markers for loaded calculation results of other models.
- An option of scaling for only one axis in the graphs.
- Dependence of 2D map scaling of the mouse position.
- For dual permeability models. An option to choose porosity system for connections in Well properties dialogue.
- An option to export 2D maps including well trajectories data.

14 **tNavigator 4.0.2**

14.1 **tNavigator kernel**

In tNavigator 4.0.2 kernel the following options are supported:

1. For compositional models in E300 format:
 - Compositional properties and EOS type for production system (surface conditions) may be specified (keywords ACFS, BICS, EOSS, OMEGAAS, OMEGABS, MWS, PCRITS, SSHIFTS, TCRITS, VCRITS, ZCRITS).
 - Relative permeabilities and capillary pressure may depend on surface tension (keywords PARACHOR, MISCIBLE, MISCNUM, MISCSTR, MISCEXP).
 - The options for gas-oil capillary pressure treatment (keyword FORMOPTS) are added.
 - Relative permeabilities scaling with respect to composition (keywords ENKRVC, ENPCVC, ENPTVC, EPSCOMP) is added.
 - Resources for fluid-in-place regions may be calculated by taking into account the separators (keywords FIELDSEP, FIPSEP).
 - Model initialization by option NEI (keyword NEI) and 11-th parameter of keyword EQUIL is supported. Also, the support for 10-th parameter EQUIL with values 2 and 3 is improved.
 - LI critical temperature correlation is supported (keywords FACTLI, LILIM).
 - The option NOMIX for oil and gas relative permeabilities near the critical point added.
 - The keyword WELLINJE is added to provide injection control data for a well.
 - The keyword GRUPFUEL is added to specify the amount of gas produced from a group that is burnt as a fuel, and thus cannot be used for re-injection.
 - Gas plants are supported (keywords GPTABLE, GPTABLE3, 7-th parameter of keyword FIELDSEP, 8-th parameter of keyword FIPSEP, 9-th parameter of keyword SEPCOND).
 - Load and save for compositional properties specified in the section SUMMARY are supported.
 - Flash calculations are significantly accelerated for single-phase hydrocarbon regions, load balancing for compositional property calculations is added.
 - The support for multiple EOS and EQUIL regions is improved.
 - Compositional models in MORE format are supported.
2. For thermal compositional models in E300 format:

- Relative permeability scaling with respect to composition (or temperature) can be combined with the scaling specified in each grid block (5-th parameter of keyword ENDSCALE).
 - K-values may be specified by the tables (keyword KVTABTn).
3. For E100 format models the following options are supported:
- Directional relative permeabilities including dual porosity case (parameters DIRECT and IRREVERS of keyword SATOPTS, keywords KRNUMX, KRNUMX-, KRNUMY, KRNUMY-, KRNUMZ, KRNUMZ-, KRNUMMF, IMBNUMX, IMBNUMX-, IMBNUMY, IMBNUMY-, IMBNUMZ, IMBNUMZ-, IMBNUMMF).
 - Gravity drainage options for dual porosity (keywords GRAVDR, SIGMAGD, SIGMAGDV, GRAVDRM, DZMTRX, DZMTRXV).
 - WAG process (keywords WCYCLE, WELLWAG).
 - Gas lift optimization (keywords LIFTOPT, GLIFTOPT, WLIFTOPT, GLIFTLIM).
 - Well prioritization option (keywords PRIORITY, GCONPRI).
 - Assigning separators to groups (keywords GSEPCOND, SEPVALS).
 - Economical limits for liquid (the 14th parameter of keyword WECON).
 - The option to decrease guide rates oscillations due to rate-dependent conning phenomena (9-th parameter of keyword GUIDERAT) is supported.
 - Automatic initialization of multiple FIP regions representing the original GAS, OIL and WATER zones (keyword FIPOWG).
 - Wettability alternation due to the accumulation of surfactant (keywords SURFNUM, SURFADDW, SURFADS, SURFROCK).
 - The option to limit permeability multiplier increase for bright-water nano-polymer models.
4. For MORE format models the following options are supported:
- Compositional models including CO_2 injection option.
 - WAG process (keyword and event WWAG).
 - The target limits for accumulated values (parameters COIL, CWAT, CGAS, CLIQ, CWIN, CGIN).
 - Well efficiency factor set by a keyword (keyword WWEF).
5. In MPI version the following options are supported:
- Numerical aquifers (keywords AQUUNUM, AQUCON).
 - TEMPerature option.
 - API tracking option.

- BRINE option (keywords SALT, SALTVD etc).
- TRACER option (keywords TRACERS, AQANTRC etc.).
- SURFACT option.
- The keyword ADDZCORN.
- The keyword WELSOMIN.
- HYSTERESIS option.
- The parameter IRREVERS of keyword ROCKCOMP.
- Average pressures WBP4, WBP5, WBP9 calculation in case pattern split between nodes.
- The keyword ARITHMETIC.
- Non-neighbour connections (keyword NNC) between blocks located on different nodes.
- The keywords SATNUM, PVTNUM in SCHEDULE section.
- The keyword WFRA.
- The export of FIPXXX maps into binary INIT file.
- The keyword PCSH (MORE).
- Creation of files listed in option –touch-after in case of job termination.
- Well production and injection reports may be outputted on each computational time step by log level set WELL LOW of keyword REPORTFILE.
- Per-node thread load balancing for properties computation.

14.2 Geology

In tNavigator 4.0.2 Geology module the following features are introduced:

- New window "tables" for view, edit, filter well objects in table form (markers, wells profiles, perforations, production data, etc).
- "Workspace"save.
- Interpolation algorithms for maps and horizons:
 - Simple, usual, universal kriging.
 - Simple, usual, universal kriging with anisotropy support.
 - Sequential Gauss simulation with anisotropy support.
 - Least squares method.
- Layer by layer interpolation for 3D data:
 - Simple, usual, universal kriging.

- Simple, usual, universal kriging with anisotropy support.
- Sequential Gauss simulation with anisotropy support.
- Least squares method.
- SCHEDULE section creation for hydrodynamic model.
- Well profile averaging for 3D grid blocks.
- Well profile creation by geology 3D data.
- Grid creation by several different properties layers.
- Arbitrary object delete is supported (markers, well profiles, perforations, well production data, etc).
- Object loading from text files with table data with column selection (markers, well survey, perforations, production data, etc).
- Edit and save parameters for object drawing.
- Windows management and navigation improved.
- Geology project may be created by existing hydrodynamic model.

14.3 Assisted History Matching

In tNavigator 4.0.2 Assisted History Matching module the following features are introduced:

- Job ordering for local job queue can be changed.
- Local PC may be switch off after all jobs in local queue are finished (for Windows only).
- Background data loading (very important for large number of variants).
- Well production target functions.
- The target function for sum of parameters.
- Well water or gas injection target functions.
- The support of Nelder-Mead algorithm.
- Well and group data is visualized in graphs, cross-plots, and histograms.
- History matching variables improved:
 - Arithmetic expressions may be used as a variable definition as for variable usage.
 - The variable type (floating point or integer) may be specified in data file.



- The cross-plots are improved:
 - Arbitrary parameter may be used as X.
 - Model data shown in cross-plots is coloured as corresponding experiment.
 - The variables can be visualized on cross-plots.
- "Tornado"plots are improved.

14.4 Remote GUI

In tNavigator 4.0.2 Remote Graphical User Interface the following features are introduced:

- The default settings for client may be specified on a server. The settings are:
 - default number of threads;
 - default number of slots used in job queue;
 - default queue name.

14.5 Graphical User Interface

In tNavigator 4.0.2 Graphical User Interface the following features are introduced:

- Conditional "if" statement is supported in arithmetic expressions for map editing.
- Dual porosity model support is improved (edit for maps in matrix and fracture, histograms for maps in matrix and fracture, etc).
- PDF viewer for documentation may be specified in settings.

15 **tNavigator 4.0.1**

15.1 **tNavigator kernel**

In tNavigator 4.0.1 kernel the following options are supported:

1. For compositional models E300 format the following functionality is added:
 - Restart both the console and GUI versions.
 - View the calculation results of compositional models during computation on a cluster.
 - Multiple EOS regions.
 - Speed of compositional calculation was increased.
 - Algorithms for determining the phase composition near the critical point was improved.
 - Compatibility with other simulators in flash calculations and phase identification was improved.
 - Parameters of VFP tables specific for compositional models.
 - D-factor in the formula of inflow to well for compositional models.
2. For E100 format models the following options are supported:
 - Hysteresis of relative permeabilities.
 - The API Tracking option: mixing of different types of oil, having different surface densities and PVT.
 - Multiphase injection (option MULTI for the 3-rd parameter of the keywords WCONINJE, WCONINJH, WCONINJP).
 - Option UDQ in the keyword ACTIONW.
 - Options LIFT and GUID for 2-nd parameter of the keywords WTMULT and WELTARG.
 - "Standard" network (keywords GNETPUMP, GRUPNET; previously only "Extended" NETWORK option was supported).
 - Reference depth for well block average pressure calculation (WPAVEDEP).
 - The dependence between well PI multiplier versus maximum water cut (keywords PIMULTAB and WPITAB).
 - Group controls for different phases for one well group (parameters 3, 4, 5 of the keyword WGRUPCON).
 - LGR models: geometry inside local grid refinement (via COORD/ZCORN and TOPS/DX/DY/DZ).



- Options for calculation of the transmissibility between the regions (5-th parameter of the keyword MULTREGT).
 - Grid in binary format for models with LGR (keyword GDFILE for models with LGR).
 - Keyword NNCGEN.
 - The calculation of transmissibility for the value ALL 5-th parameter of the keyword PINCH was improved.
 - Options of the command line `-touch-before`, `-touch-after` to create files (specified by user) before of after calculation.
3. For MORE format models the following options are supported:
- VFP tables specification.
 - User-files in E100 format are possible in MORE format models (for example, to set the proppant properties tables or automatic hydraulic fracture).
 - FIELD units.
4. In MPI version the following options are supported:
- Restart for compositional models.
 - Hysteresis of relative permeabilities.
 - Output of PLT binary files (keywords WRFT, WRFTPLT).
 - Output of binary files, managed via the keyword OUTSOL in SCHEDULE section.
 - Output of a set of vectors for the keyword ALL in section SUMMARY.
 - Option STORE of the keyword ROCKOPTS.
 - Option SMARTMB of the keyword RUNCTRL.
 - An automatic restart from the beginning of reporting step with the minimum initial time step, if the calculation for one reason or another has not converged.

15.2 Geology

In Geology module the following new functionality was added:

- Calculator of all objects.
- The history of the objects. Tool to recalculate objects with different parameters.
- The well profile with an ability to edit markers.
- A tool for creating and editing of the coordinate system (is used for the grid construction).
- Taking into account a polygon (for example, the license block) in the grid construction.

- A tool for creating and editing of polygons.
- A tool for creating and starting the model (sections RUNSPEC, GRID, PROPS (with correlation), SOLUTION).
- Information window (calculation details).

15.3 Assisted History Matching

In Assisted History Matching module the following new functionality was added:

- An ability to work with integer variables in history matching.
- An algorithm of relative permeabilities history matching (Corey correlation).
- Option "Connect to the model" (view results for models that are calculating at this time).
- For any variant of history matching project the table "Variant Info" is enable (double click on the variant in the option Project Info). Table can be exported to html.

15.4 Remote GUI

In Remote Graphical User Interface the following options were added:

- The design of the main window was modified: an ability to configure location and form of tools.
- Now one can add a variety of models, including specification of the directory where tNavigator searches all data files.
- An ability to load configuration of running processes from the server.

15.5 Graphical User Interface

In Graphical User Interface the following options were added:

- Graphs of component production for compositional models.
- An ability to load results of the model that in calculated at this moment.
- LGR blocks are displayed via grey color at the map of roof.
- 2D maps of sum, average, rms, ... : LGR blocks borders are displayed as dotted line.
- An ability to display the time steps with a precision better than days (hours, minutes).
- An ability to customize the accuracy of the numbers in the tables for graphs.
- The symmetric logarithmic palette for maps with positive and negative values.
- An ability to visualize crossplots for regions for historical and calculated graphs simultaneously.

16 tNavigator 4.0.0

16.1 tNavigator kernel

In tNavigator 4.0.0 kernel the following functionality is supported:

1. Compositional models in E300 format are supported:
 - the standard set of options for compositional modeling is supported (except for an injection of CO₂);
 - calculation of compositional models is supported in the cluster (MPI) version;
 - for compositional models in the GUI all visualization options are added.
2. "Black oil" models calculation in IMEX format is supported.
3. New module – geology modeling – is added:
 - loading trajectories, markers, LOGs, horizons;
 - creation of horizons by markers;
 - creation of mesh by horizons;
 - interpolation of cubes from LOGs (via the formula) (creation of cubes: net-to-gross ratio, porosity, permeability);
 - export of mesh and cubes into a corner point geometry format (COORD/ZCORN);
 - saving of log of all data operations;
 - 2D and 3D visualization of all data.

This module allows to create a geological and hydrodynamic model using a primary processed information in a single interface.

4. New module – Assisted History Matching module – is added (this module is based on Experiment designer):
 - Optimization algorithm (differential evolution) was added. This algorithm allows to minimize the mismatch in the adaptation in automatic mode, via changing of parameter values.
 - Construction of user-defined objective function (weighted sum of residuals) in GUI. The objective function can be constructed for any group of wells in basic model. Oil, water, liquid, gas (rate or total), watercut or gas-oil ratio can be used.
 - New algorithm (creation of model variants) can be run from previously created initial approximation (model variant) in the History Matching window. Variants generated by different algorithms are compared in a single window.
 - A new algorithm for estimating the sensitivity is added - tornado experiment, which allows to make a tornado diagram.

- Assisted History Matching for E100 and MORE data models. "Manual" specification of variables for E100 format models (the keyword DEFINES) and MORE format model (the keyword VDEF).
 - Variables for history matching can be specified in GUI (history matching of WOC, GOC).
 - Saving of History Matching Project (the state of History Matching data) to the file which is portable between computers and operating systems.
 - The integration of the model queue to a remote task queue on the cluster.
5. Remote GUI (graphical interface) module is added. This module allows the user to do the following things from his workstation (running under Windows or Linux):
- put a model in a queue for the calculation on remote cluster;
 - delete a model from the queue;
 - view the status of the queue;
 - view the status of the calculation (progress and calculation log);
 - connect to the current calculation and visualize the calculation results.
- In fact, this module makes the calculation on the remote cluster the same convenient, as well as the calculation on the local computer.
6. For models in E100 format the following keywords are supported: JFUNCR, GSATPROD, GSATINJE, GCONSUMP, WELPI, RPTRST (options FREQ and BASIC).
7. For models in MORE format the following keywords are supported: DPOR, DPER, DPSS, LOCAtion, ZONE. Dual porosity is supported for models in MORE format. Splitting and merging of MORE format models is supported.
8. For models in MORE format the new possibility to add a hydraulic fracture is added: a table with events (new *tNavigator* keyword – WFRP – is analogous to the keyword WFRACP for models in MORE format).
9. A possibility to specify the relative permeabilities tables with Corey correlations via the keywords COREYWO and COREYGO.
10. Support of options in MPI version is improved:
- dual porosity and dual permeability models are supported;
 - restart is supported;
 - saving of E100 binary files is supported;
 - the continuation of the calculation from the last calculated step is supported;
 - compositional and temperature models are supported.

11. The possibility to open on another computer the results of calculation, that goes on the cluster, if the model is calculated on the shared disk.
12. The GUI can be used to view the results of calculated models without a full license (GUI may have it separate licensing).

16.2 Graphical User Interface

The GUI version of tNavigator 4.0.0 has the visualization of new physical models and new modules:

- Compositional model;
- Geology;
- Assisted History Matching;
- Remote GUI.

The following functions are added:

1. For User maps and User Cuts: the calculator is added. Calculator buttons are names of available maps and available operations with them. For 2D map Layer selection of any area with "brush" can be used. Calculator simplifies the work with User Arithmetic.
2. A possibility to enter the injected tracer name and its concentration in the GUI in the Well Properties dialogue.
3. A possibility to enter the economic limits for wells in GUI in the Well Properties dialogue.
4. The interface for perforating the well along it's trajectory is improved.
5. The interface for tracer graphs is improved.
6. A possibility to use the economic parameters (enter in GUI tax values, cost of operation, new drilling, geological and technological procedures).
7. A possibility to create a well trajectory on Cross-Section.
8. Dynamic creation of WELL LIST in GUI. Visualization in GUI of WELL LIST that are specified in model files and in GUI.
9. Binaries converter (from binary files to text files) is added.



17 tNavigator 3.3.4

17.1 tNavigator kernel

In tNavigator 3.3.4 kernel the following functionality is supported:

1. Work with dual porosity models has been improved:
 - local grid refinement (LGR) for dual porosity models is supported;
 - arrays in EDIT-section can be changed for dual porosity models.
2. Work with models with a large number of inactive blocks has been improved:
 - Loading models with a large number of inactive blocks is accelerated;
 - Restart models with a large number of inactive blocks is supported.
3. Splitting a large model into small sectors has been improved:
 - Splitting models with a large number of inactive blocks is supported;
 - Splitting models with group control is supported.
4. MPI version options are upgraded:
 - keyword ACTION can be used with a limited amount of stored information;
 - option CHECKSAT of the keyword RUNCTRL;
 - a single run of calculations provides splitting of a large model into sectors and calculation of the boundary conditions;
 - restart of regular version with the calculation of MPI version.
5. Support for numerical aquifers has been improved.
6. The second parameter of the keyword GRIDUNIT (E100).
7. New Interpolation method has been added - multilayer and 3-dimensional Sequential Gauss Simulation.
8. Protection from damage of result files was added in the case when one model is opened simultaneously by multiple instances of tNavigator, including on the shared disk.
9. New elements of the automatic adaptation:
 - Experiments designer. Creation of the different model variants with different variable values modified by one of the following algorithms: Grid Search or Latin hypercube.
 - Sensitivity analysis tool: Pearson correlation between the model variables and the values of parameter mismatch.
10. The model queue. The opportunity to send a notice to e-mail when the model calculation is finished.

17.2 Graphical User Interface

In tNavigator 3.3.4 Graphical User Interface the following functionality is supported:

1. To support the functions of Experiments designer the list of functions to compare the results for the queue models is enlarged. The following features were added:
 - Graph of difference between the calculated and historical values.
 - Values Crossplot for selected calculated models.
 - Export to a text file for histograms, graphs and tables.
 - Sorting of the selected models.
 - Deleting of non-selected models.
 - Mark the selected models in the table of values and residuals for copying to the clipboard.
 - Selecting displayed columns in tables of values and residuals.
 - Hiding parameters with the same values in the tables and histograms.
 - Ability to set the historical values from the selected model to calculate the residuals and compare results.
2. The functionality of cross-sections has been upgraded:
 - Cross-sections can be made through a fence, specified via individual points, horizontal well or several wells.
 - Map Editing. the possibility to edit map inside or outside the cross-section (analogously to the profiles).
 - Cross-section through the well can be made: through the centers of blocks with connections or through the trajectory branch. Smoothing (reducing the number of trajectory points) with the selected precision can be done.
 - Cross-section through the several wells. Wells can be chosen from the Well filter or Well selection. Wells order can be changed in the list. Cross-section can be made through well top, bottom or middle part.

18 tNavigator 3.3.3

18.1 tNavigator kernel

In tNavigator 3.3.3 kernel the following functionality is supported:

1. Calculation of dual porosity (and dual permeability) model is modified, working with these models is accelerated.
2. Artificial Lift Quantity (ALQ) is supported in lifting-tables and in well control modes (E100).
3. 3-rd parameter of WEFAC (E100).
4. Cross-flow blockage (ALLX) in MORE models.
5. LGR in MORE models.
6. LGR in values interpolation into crosshole space.
7. Values interpolation into crosshole space is accelerated (for Multilayer Geostatistical (Kriging) interpolation Type).
8. Map Editing. In Multilayer Determined interpolation a new parameter "Radius" is added. Radius has influence on smoothing near well.
9. Map Editing. Connected Components and Voronoi Diagrams are added.

18.2 Graphical User Interface

In tNavigator 3.3.3 Graphical User Interface the following functionality is supported:

1. Calculation of historical data is done when model is open, so model loading is accelerated.
2. Graphs. Well list. Historical or calculated well status is shown.
3. Playback results function is added.
4. Automatic creation of screenshots for several time steps.
5. Acceleration of 2D and 3D maps for large models.
6. User Interface for dual porosity and dual permeability models is updated.
7. Automatic selecting of integer layers for Contour lines. Previous behaviour (uniform partition of the range of values into intervals) can be chosen in Preferences. Visualization.

8. Loading of User contours for profiles.
9. Improved navigation of logs (Option "Find" is added).
10. User Arithmetic description is updated. Option "Find" is added.
11. Models queue is changed:
 - models queue is in the new window (queue status is saved);
 - one can make several models queues and choose one to work with;
 - historical values visualization for models from queue and residual histograms for calculated models;
 - visualization of values for calculated models at any time step.



19 tNavigator 3.3.2

19.1 tNavigator kernel

In tNavigator 3.3.2 kernel the following functionality is supported:

1. Option NETWORK is enlarged (E100): compressors, booster compressor station, water discharge at the network nodes.
2. Separators are supported (E100).
3. Boundary conditions record for model splitting have been updated.
4. ROFF format for initial grid data is supported.

19.2 Graphical User Interface

In tNavigator 3.3.2 Graphical User Interface the following functionality is supported:

1. Adding well is via Alt+Click (earlier – Ctrl+Click). Commands "Show Block Info (graphs)" and "Add well" have different control sequences.
2. Selecting of nearest to the mouse well on 2D map.
3. Visualization of well groups and wells in these groups (for all graphs).

20 tNavigator 3.3.1

20.1 tNavigator kernel

In tNavigator 3.3.1 kernel the following functionality is supported:

1. Increased support for open models with a large number of inactive blocks: multireservoir models are supported, splitting of such models is supported and boundary conditions creation.
2. Saving and splitting of multireservoir models.
3. Calculations of the split patterns in MPI-version.
4. The ability to write the boundary conditions without opening .patterns-model.
5. The drawdown limit can be taken into account when calculating the well's production potential (WELDRAW, item 4) (E100).
6. The maximum drawdown within the set of connection grid blocks (WELDRAW, item 5) (E100).
7. Group reservoir fluid volume production rate control (GCONPROD RESV) (E100).
8. The keyword GEFAC (E100).
9. **COMPDAT AUTO** – connection is initially closed. It will be opened automatically when another well connection is closed during an automatic workover. A connection on AUTO is opened each time the well is worked over, in the order in which the connections are first defined in COMPDAT. (E100).
10. Prioritized drilling queue. Sequential drilling queue (keywords WDRILTIM (item 1-2), WDRILPRI (item 1-2), DRILPRI (item 1-9)) (E100).
11. Removed the generation of files EGRID, INIT, UNRST when using the option-d (E100).
12. Algorithm of evenly balancing the allocated memory between the NUMA nodes was improved, calculations on systems with NUMA architecture was accelerated.
13. Added a section of a hybrid time-dependent data in the hybrid model. (model E100 + MORE time-dependent data + additional time-dependent data E100).
14. Models MORE with temperature option.



20.2 Graphical User Interface

In tNavigator 3.3.1 Graphical User Interface the following functionality is supported:

1. New visualization of Well section (Well profile) and LAS files.
2. Interpolation on 3D maps:
 - (a) geostatistical interpolation (kriging)
 - (b) determined method (least square method)
3. A simplified way to create perforations filters in layers is added.
4. A possibility to create compact window with graphs for selected parameters.
5. A possibility to create a well filter via selecting wells on a 2D map.
6. Synchronization of well filters for all windows.
7. A possibility to delete well filter.
8. In model statistics, the model values are now written with the factors (thousand, million).
9. An acceleration of the interface with large models.
10. A possibility to create a filter (cut) for faults.

21 tNavigator 3.3.0

21.1 tNavigator kernel

In tNavigator 3.3.0 kernel the following functionality is supported:

1. Dual porosity and dual permeability (E100) is supported in calculations and in graphical interface (in tracers calculations, salts, polymers, temperature option).
2. Option to limit the rate of inverse gas dissolution is supported (DRSDT).
3. Number of supported parameters in the following keywords increased (E100): WELDRAW, WECON, WECONINJ, GECON, PPCWMAX, GPMAINT, WCUTBACK, GCONINJE, GCONPROD.
4. Multiple group controls is supported (E100, MORE).
5. The keyword WFRAC is supported for MORE models; and its expansions (for example FLOWFUNC) that was supported earlier only for E100 models.
6. Restart for MORE models is supported.
7. Support of unit systems has been improved (FIELD, METRIC), also in user arithmetic (E100, MORE).
8. Section SUMMARY for E100 models is supported: when one orders export of results to binary files E100 (UNRSMRY) they are saved in accordance with the specified in the section SUMMARY fields. Graphical interface to choose export fields has been added.
9. The keywords OUTSOL and RPTRST for E100 models are supported: when one orders export of results to binary files E100 (UNRST) they are saved in accordance with the specified in the keywords fields. Graphical interface to choose export maps has been added.
10. In the keyword GDFILE in addition to the binary grid format EGRID mesh GRID (E100) are supported.
11. Hybrid model mode: up to section of non-stationary data it has the format E100, the section describing the trajectories, events, well data has the format MORE.
12. In Surfactant model adsorption is taken into account (E100).
13. In polymer model Bright Water temperature option is taken into account.
14. Faster calculation of the historical data while loading model (E100, MORE).
15. Temperature option is expanded beyond E100: a) heat capacity of blocks with non active blocks can taken into account in temperature calculations, b) one can set the heat exchange with the environment (top and bottom layer).

16. The ability to write concise event of perforation, while saving the model (in demand by splitting-merging the model and the desire to further manual editing) (E100).
17. Dates to 1900 year are supported (E100, MORE).
18. To reduce the amount of data (written to disk) the file containing flows between the FIP regions is generated only by user request (E100, MORE).
19. First implementation of geomechanical option.
20. Default values in the input maps are supported.
21. For the cluster version: support for GDFILE, multi-reservoir models, all types of group control, an optional recording of the entire set of results files (E100).
22. For the console version (including cluster version): an explicit entering from the command line a set of results files that will be generated. For example, one can specify a record of results for groups and wells to reduce the amount of required disk space and to reduce time. Generated graphics then can be viewed in a graphical interface.
23. For the console version (including cluster version): command line option `-thread-bind-to-cpu` to explicitly specify the binding of threads to logical processors.
24. Improvements in balancing between the NUMA nodes used by the program RAM.
25. Improvements in the use of CPU cache.
26. Speed of calculation of sector models with boundary conditions was significantly increased (FLUX).
27. Different options in calculating the local grid refinement (LGR) were supported (nested LGR, options PINCH, streamlines).
28. Improvements in the calculation of the initial equilibrium (a significant acceleration in some cases; transit zone and the accuracy of equilibrium are supported, etc.).

21.2 Graphical User Interface

In tNavigator 3.3.0 Graphical User Interface the following functionality is supported:

1. An ability to read only the time-dependent model data (schedule data) for E100, MORE models, hybrid format. This can highly speed up adaptation work, if only wells and perforations data was changed.
2. Local mesh refinement (LGR) is supported in all parts of the GUI: 2D and 3D maps, contour lines, in user arithmetic, editing maps, adding new wells.
3. Adding perforations dialog can use the trajectories. Now, if the well trajectory is loaded, the perforations can be added in format "from - to" in TVD or MD (E100, MORE).

4. An ability to additional loading well data and storing it in a table-text format (similar to **MORE** format).
5. A map of the ternary diagram for saturations.
6. In settings one can choose the control style **IRAP** or **Petrel** in 2D and 3D maps.
7. If the map Cut is enable, then by selecting the "Wells" shows the sum of all perforations, selected by this Cut.
8. An ability to rename profiles and well filters. So profile name is used now instead of profile number.
9. In User Arithmetic expressions one can use relative permeabilities scaling, even if they have not been explicitly defined (**E100**, **MORE**), and maps of aquifers connections.
10. Setting to control the accuracy of signatures to the isolines.
11. Loading cubes from files .grdecl format was improved (now one can download the data inside the **BOX / ENDBOX** structure).
12. Maps of minimum and maximum for 2D maps.
13. Creation of well filter, taking into account the Unified Adaptation Results table.
14. An ability to sort the wells using Unified Adaptation Results table data.
15. An ability to assign a name for the Annual Summary Report.
16. Visualization of **ROCKTAB** (**E100**), **KVSP** (**MORE**) data.
17. Visualization of vector fields for the geomechanical option.
18. An ability to save a picture of map or graph to the clipboard by pressing the camera button.
19. An ability to import well filters from the clipboard.
20. Factors (thousand, million) in tables and graphs are now the same for the graphs on the same axis.