



СВЭАТМОУТАЖАВТОМАТИКА

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COMPANY

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SOFTWARE COMPLEX
FOR AUTOMATED STRUCTURAL LOGIC SIMULATING AND COMPUTING
OF RELIABILITY AND SAFETY MEASURES OF CONTROL SYSTEMS

USER MANUAL

(SC ASLS SZMA, version 0.1, base sample)

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INTRODUCTION

The *Software for Automated Structural logic Simulating and computing of reliability and safety measures* (SC ASLS) was developed by **SPIK SZMA** to support the design process of *Automated Process Control Systems* (APCS) and to perform reliability & safety analysis of other large-scale, structurally complicated objects & processes.

The SC ASLS SZMA performs the following main functions:

1. Automated simulation and computing of reliability and safety measures of any APCS. Conditions of functions realization & emergency occurrence are represented by means of *functional integrity schemes* (FIS) and *logical criteria of functionality* (LCF);
2. Automated generation of logic and probabilistic mathematical models for large-scale structurally complex APCS;
3. Automated computing of APCS reliability and safety measures;
4. Simulation and graphic display and storage of results. The RezAcm.lst file can be used for the development of technical and economic assessment of project solutions related to the APCS's reliability and safety.

The SC ASLS SZMA's theoretical base is a general logic probabilistic approach and automated structural logic simulating theory and technique [1-2].

The SC ASLS SZMA (at all simulating levels – structural, logic, and probabilistic) supports all capabilities of Boolean algebra simulating in the operational basis AND, OR, NOT. It therefore, can perform almost all logic probabilistic simulating tasks solved by other simulating theories and techniques (fault-trees, event trees, connectivity graphs, etc.), and, moreover, a new class of non-monotonous analysis tasks applied to complex objects & processes.

The present SC ASLS SZMA is a base version. It provides end-to-end solution for main standard tasks of all stages of reliability and safety analysis's logic probabilistic technique. It is possible to solve specialized tasks of reliability & safety simulation and computing, operation risk estimation, and control decisions technical and economical support through further development and adaptation to new task classes and data domains.



Chapter I. BASICS OF THE SOFTWARE OPERATION

1. General Provisions

1.1. If the SC ASLS SZMA is not installed on your computer, then see Chapter 2 for installation procedures.

1.2. Before using the installed SC ASLS SZMA for reliability and safety measures simulation and computing, the user should prepare the following initial data:

- Study the object and make preliminary formalized logic description of the system's functionality criterion realization by the system elements (for example, system's availability, failure, emergency occurrence / non-occurrence, etc.). Preliminary formalized description can be made in any logically strict structure form, for example, using FIS, fault-trees, event trees, series-parallel connection (flowchart), connectivity graph, etc;
- Develop (based on the initial formalized description) the system's functional integrity scheme (one or more);
- Specify logical criteria of the system functions that determine conditions of its main functions realization (or non-realization), emergency occurrence (non-occurrence);
- Determine probabilistic and other parameters of the system elements.

1.3. The SC ASLS SZMA startup, prepared initial data input, and automated simulation & computing of the system's reliability and safety measures (Chapter 3, Part II, III, and IV).

1.4. Results software for development and support of research, project, operation, and other management decisions.

2. Software Installation and Start-up

2.1. Scope of Supply

The Software is supplied on CD-ROM.

The Scope of Supply includes the following main components:

- Packaging box;
- CD-ROM with Setup files and license key;
- License Agreement;



- User Manual.

2.2. System Requirements

To run the software, the following operating systems are required: MS Windows 95 – Me, Windows NT–2000, or higher. For a full-value operation of the Software, the following hardware is recommended:

- PC with Pentium 90 Processor or higher;
- CD-ROM drive;
- 32 MB memory or more
- To ensure the Software & large-scale FIS operating speed, 128 MB memory or more;
- 5 MB hard-disk space or more;
- VGA monitor minimum, Super VGA with 256 colors ore more and 1024x768.

To print reports & FIS, printing unit (printer, plotter, graph plotter) with its software is required to be used.

2.3. Installation

Install CD-ROM setup disk and open [Setup] file. In the system folder [Program Files] a new folder [ASLS SZMA] is automatically created, where the Complex work files are stored.

Archive files are unpacked during installation. Installation duration depends on the computer and CD-ROM operating speed.

2.4. Software Start-up

After the setup is completed, the SC ASLS SZMA startup icon is displayed in the main Window's Menu (<Start> <Programs>) and on the desktop. This icon is shown in Fig. 1.



ASLS SZMA

Fig. 1. The SC ASLS SZMA Startup Icon

After the Software is running, the SC ASLS SZMA's Main window is opened (Fig. 2).



The Software's Main window includes the following four segments:

1. Main box, located in the upper part of the Complex's Main window, consists of four bars:
 - Title bar;
 - Main Menu bar;
 - Two control element toolbars.
2. The system's FIS Input box;
3. Box for elements' parameters input and automated simulation mode setting;
4. Simulation and computing results output box.

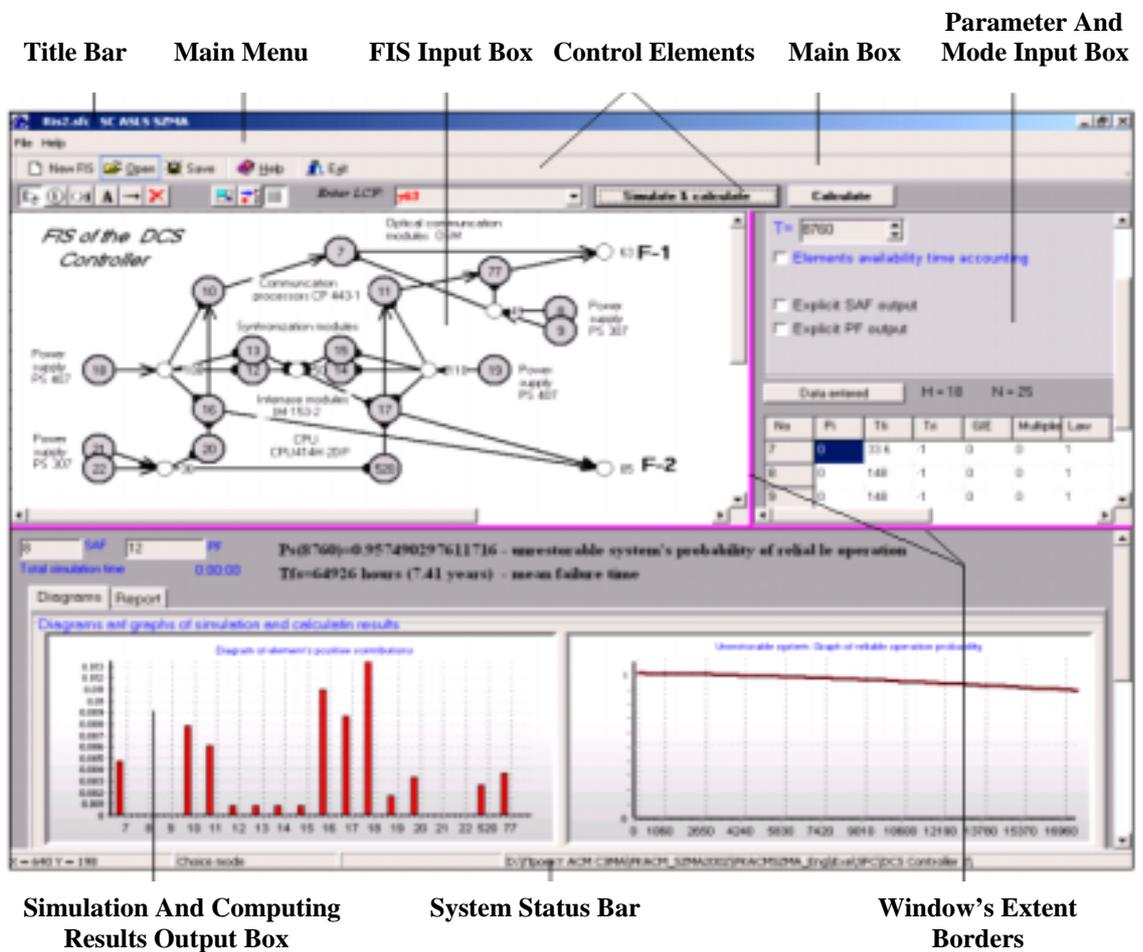


Fig. 2. The SC ASLS SZMA Main Window



2.5. Window Resize

The Software has an option to resize vertical and horizontal borders of FIS Input Box, Parameter Input Box, and Results Output Box (Fig. 2). These borders are displayed in crimson. To resize a window, point to the window's border. When the cursor becomes a two-headed arrow  (crHSplit), drag the window's border (right/left, up/down) to the size you want.

The scroll bar is used to guide through the contents of a window.

3. Software User Interface

User interface is defined as a set of graphic shell's objects used for the mouse and keyboard control. Control is defined as a set of actions to input initial data (FIS, LCF, element's parameters) into the SC ASLS SZMA and to set automated simulation, computing, results output, & documentation modes.

The SC ASLS SZMA's user interface adheres to the standard Microsoft Office software interface which makes using the software easier for specialists experienced in standard Windows GUI environment.

All SC ASLS SZMA's control and information objects have context tips: to display them point to the object and hold the cursor for 2 seconds.

3.1. Basic Control Components

The title bar is located at the top of the Main Window (Fig. 2). After the Software starts the Title bar displays the program name – “**Software for automated structural logic simulating SC ASLS SZMA**”. When the FIS is developed, saved or opened, the Title changes into *{FIS name}* SC ASLS SZMA. Three standard control buttons (minimize, maximize, close a window) are located at the top right hand corner.

 – Main window Close button that closes an open window (exits the Complex).

 – This button is displayed when the Main window has a standard medium size. Click this button to expand the window to the full screen size.

 – This button is displayed when the Main window is at its full screen size. Click this button to return the window to its standard medium size. Another way to minimize/maximize the Main window is to double-click on the title bar.

 – Main window Close button.



The main menu bar is located under the title bar. Two toolbars with shortcuts are located under the main menu bar. These shortcuts partly duplicate the Main menu, options, ensure the FIS graph input, the LCF input, automated simulation & computing startup.

3.2. Main Window Resize

To resize the Main window, drag its corner or edge. Move the pointer to the window's edge until the pointer changes to the double-headed arrow: up/down - for vertical resize, right/left – for horizontal resize. Then left holding the mouse button down, drag the border in the desired direction. Release the mouse button to fix the new window size.

The Main window is resized in two directions at once while dragging any of its corners. The pointer changes to double-headed diagonal arrow.

3.3. Main Window Relocation

To move the whole window, point to the title bar, then holding the left mouse button down, drag the window to the desired location. While moving the Main window, it is shown as a frame. A full screen window cannot be moved.

3.4. Multiple Complex Operation

To work with several projects at once, start the Complex as described above (item #2.4.), then click  and close the Main window. Start the Complex again: the second active Complex's window will be displayed. The first-opened, currently non-active Complex's attributes will be located on the Windows Status bar. To make this software active, click its attributes' button.

To have both softwares' windows displayed at once, click  to restore the standard window's size, and then decrease the active window's size to the half screen (item # 3.2.). Then click the second software's button on the Windows Status bar to make it active. Do the same operations with this window as described above. As a result two softwares' windows will be displayed at once.

3.5. The Software's Main Menu

3.5.1. Main Menu Overview

The Complex's Main menu includes the following two items:

- File - operations with project files;
- Help – SWSM SZMA's help information.



3.5.2. Main Menu Operation

Each Main menu's item can become active: point to the item and left click the mouse. Commands list of the menu item is opened. Commands lists of the main menu's items are shown in Fig. 3.

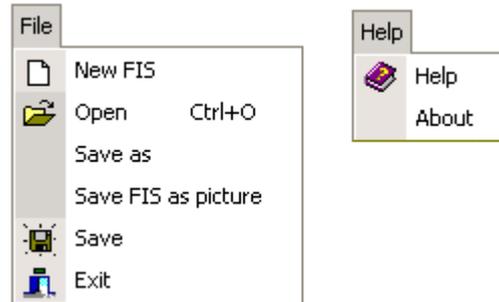


Fig. 3. Main Menu Commands

Current available commands are shown in regular type, while non-available commands are shown in shaded type. To move through the submenu list, select and call the command, use the mouse or keyboard up/down buttons.

Another way to call the menu commands is to hold down the {Alt} key and at the same time press shortcut letter key underlined letter in each menu item (Fig. 3). Latin letters should be installed.

3.5.3. File Menu Commands

This menu item includes a set of file operations options.

File menu options are shown in Fig. 3. On the right are the shortcut keys to call the commands without using the mouse.

File menu options' functions are shown in Table 1.

Table 1.

Option	Function
New FIS	Opens a new FIS Input box (Fig. 1) to develop a new FIS graph.
Open	Opens the standard dialog box Open File for the already developed and saved FIS opening.
Save as	Opens the standard dialog box Save As for the user's file name specification and developed FIS saving.
Save FIS as picture	"FIS input box" image is saved in the .bmp file.
Save	Saves changed FIS in the file with already set filename.
Exit	Terminates the Software.



3.5.4. Help Menu Commands

This menu item includes a set of SC ASLS SZMA’s help information options. These options are shown in Table 2.

Table 2.

Option	Function
Help	Opens the Complex’s help information.
About	Opens the message window About SC ASLS SZMA.

3.6. Backup Main Menu Bar

This Bar is located in the third line of the Main window (Fig. 1) and is shown in Fig. 4.

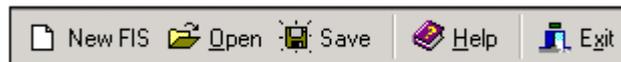


Fig. 4. File menu options shortcuts

These shortcut keys duplicate the File menu options (Fig. 3 and item # 3.5.).

3.7. Toolbar (Command Shortcuts)

The shortcut keys toolbar is located in the forth line of the Main window (Fig. 1). These shortcut keys are used for the FIS graph input and correction. The shortcut keys functions are shown in Table 3.

Table 3.

Key	Help	Function	Mode
1	2	3	4
	Selection	Sets the graph mode Selection	Selection Mode
	Function Node	Sets the graph mode for the function node input	Node Mode
	Dummy Node	Sets the graph mode for the dummy node input	
	Text	Sets the graph mode for the explanatory text input	Text Mode



	Arrow	Sets the graph mode for input of the arrow between nodes	Arrow Mode
	Delete	Sets the graph mode for the FIS's objects deletion	Deletion Mode
	Change Window's Extent	Opens the window for the FIS input box resizing	---
	Load Background Image	Opens the window for the selection of the file with background image	
	Show Grid	Opens the grid mode for the objects placement within the FIS input box	

3.8. System Status Bar

The Status bar located at the very bottom of the Main window is shown in Fig. 5.

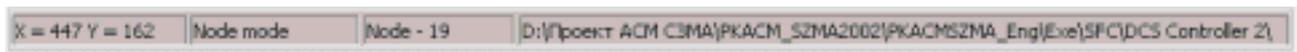


Fig.5. The Software's Status bar

The Status bar consists of 4 sections:

- In the first section, the mouse cursor's point coordinates within the FIS input box are displayed. Point coordinates are displayed in pixels. Point of origin is located in the left hand top corner of the FIS input box. When the mouse is moved (within the FIS input box), point coordinates change;
- In the second section, current mode of the FIS graph operation is displayed. It is defined by the last pressed shortcut key. Mode names are shown in the last column of the Table 3;
- In the third section, number of the active node (selected by the user) or of the FIS graph's Connection Arrow (selected by the user) is displayed;
- In the fourth section, the full path to the working folder with project FIS files and results folders is displayed.



Chapter II. FIS INPUT AND EDITING

4. Operation Basics

The software has the option to open a new FIS graphic or to open an existing FIS.

4.1. FIS Creation And Saving

4.1.1. New FIS Creation

To create a new FIS click the File menu command <New FIS> (Fig. 3) or click  on the toolbar. In the FIS input box a new FIS graphic input workbox is opened. The FIS input box becomes white (as shown in Fig. 6) and FIS graph development control keys become available.

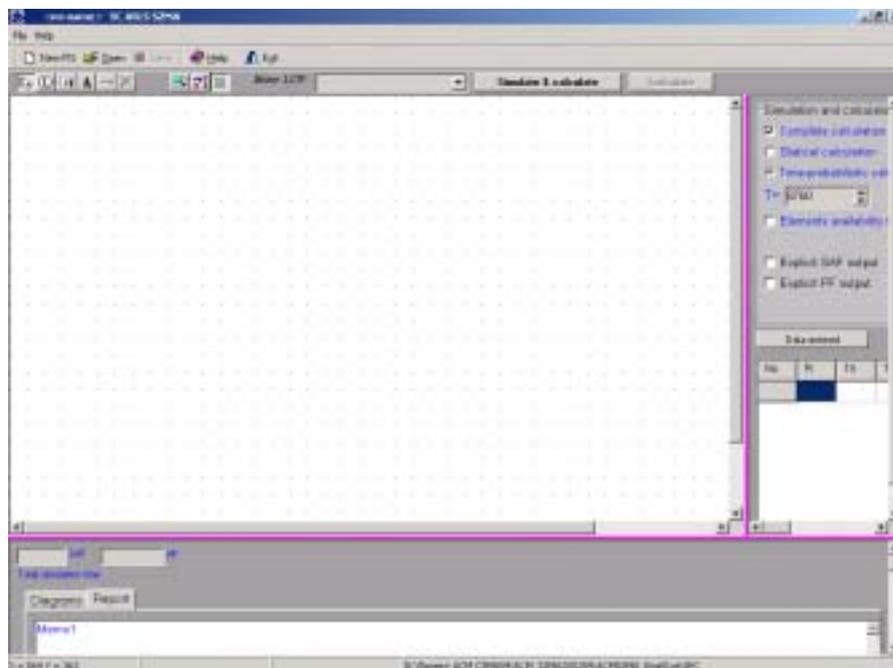


Fig. 6. The Main window after clicking “NEW FIS”

Standard default size of the FIS input workbox is 995 x 585 pixels.

4.1.2. Developed and Saving FIS

To save the FIS for the first time, click the File menu command <Save As> (Fig. 3). Standard dialog box opens. It is shown in Fig. 7.

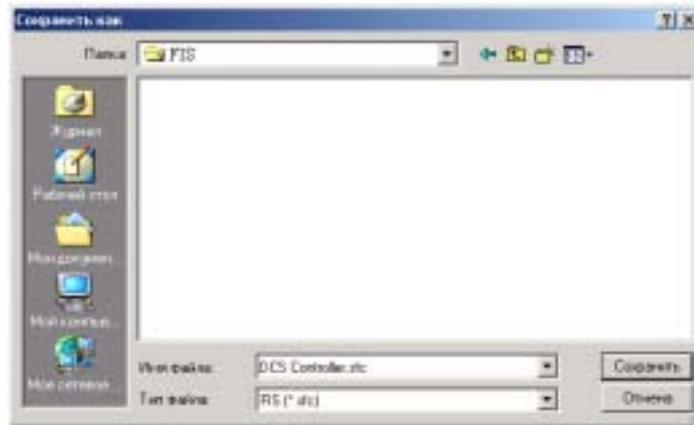
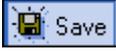
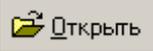


Fig. 7. The FIS Save dialog box

Specify the FIS name in the File Name entry line. Default filename extension ".sfc" is set. Then press Save button. Press Cancel button to cancel saving the FIS.

To Save new changes of an already saved FIS file, click the File command <Save> or click  on the toolbar. The File name input box does not open. The FIS is saved in the opened file.

4.2. Opening And Editing an existing FIS

There are two ways to open an existing FIS: click the File menu command <Open> (Fig. 3) or click  on the toolbar. The standard dialog box opens. It is shown in Fig. 8.

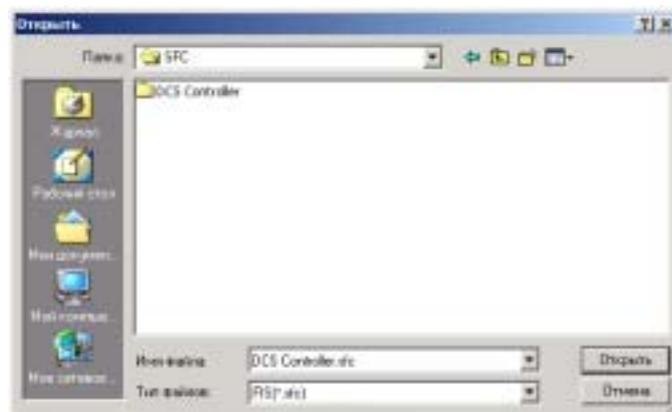


Fig. 8. The Open FIS dialog box



A list of previously saved FIS folders is displayed. Each folder corresponds to one FIS. Select the required folder. To open the folder, left double-click it. Select the file with "name.sfc" extension. Press Open button. Press Cancel button to cancel opening the file.

4.3. FIS Input Box Resize

When a large-scale FIS is created, the default input and editing box size (995 x 585 pixels) may not be sufficient. To increase the FIS input workbox size, click  (Change Window's Extent) on the Toolbar (Fig. 2). Dialog box opens shown in Fig. 9.

Dialog box slidebars are initially set to fit the default FIS input box size. Move slidebars using the mouse to set the desired FIS input box size. While moving slidebars, the Status bar numbers show the current box's size (in pixels).

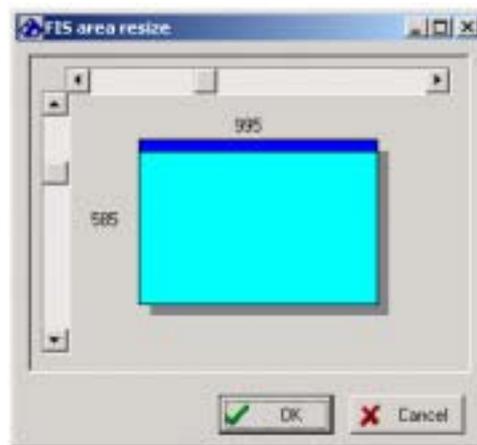


Fig. 9. The FIS area resize dialog window

When the FIS input box size is set, click OK. Dialog box closes and the FIS input box size changes. Click Cancel to keep the FIS input box size unchanged.

If the resized input box does not fit the screen, scroll bars automatically appear to display parts of the large-scale FIS.

4.4. Background Image Loading

The Software has an option of loading an image as the FIS input box background. The image is created in the special Editor and saved in the file. To load the image, left-click  (Background Image Loading) on the Main window's shortcut toolbar (Fig. 2). The Image file



loading dialog box opens. It is shown in Fig. 10. Select the required Image file and click Open. The image will be loaded into the FIS input workbox. FIS input box size will automatically change to fit the image size. Click Cancel to cancel the image loading.



Fig. 10. Background Image loading dialog box

5. FIS Input Box's Main Objects

During the FIS input and editing, the following graphic objects are used:

- Function node that represents the system's elements in the FIS graph;
- Dummy node that does not represent any system's elements, but is used in the FIS to display complex logic connections and elements relations;
- Connecting edge that in the FIS represents elements & subsystems logical connections and relations;
- Equivalented function node that in the main FIS graph represents the subsystem which structure and elements set are described by another second-level FIS subgraph;
- Explanatory text that in the FIS represents titles, comments, and explanatory notes.

5.1. Function and Dummy Nodes

In the SC ASLS SZMA, function and dummy nodes operate similarly. The only difference is the mode setting shortcuts keys *Function Node* and *Dummy Node* on the shortcut toolbar (Fig. 2, Table 3). Other operations are the same.



5.1.1. Adding a Node to the FIS Graph

To input a function node into the FIS, left-click  on the shortcut toolbar. This button is fixed and a Node Mode is set. Then moving the mouse within the FIS input box, choose the node location, and left-click the mouse to input the node into the FIS graph. In the chosen location a new node will appear. The node will automatically get the next serial number.

To input a dummy node, click  and then perform the same operations as described above.

5.1.3. Changing Node Background Color

To make the FIS clearer and more informative, the node background color can be changed. Point the mouse to the node and right-click. Near the chosen node a pop-up menu appears. This pop-up menu is shown in Fig. 11.

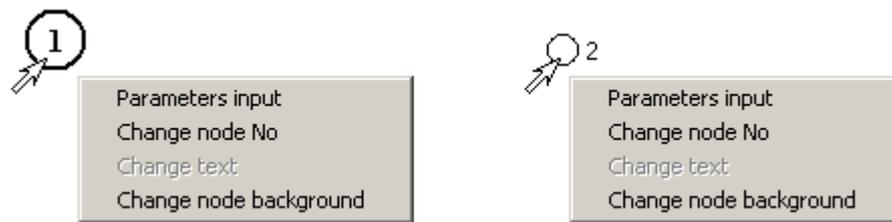


Fig.11. Node Contextual Menu

Click the option <Change Node Background>: The standard Color selection dialog box is displayed (Fig. 12).



Fig. 12. Color selection dialog box



Select the node background color and click OK. The dialog box closes, and the node background changes its color. Click Cancel to leave the node background color unchanged.

5.1.4. Changing Node Numbers

The main system FIS and each subsystem FIS (equivalented node) contains function and dummy nodes. Each node within each FIS has a unique number from 1 to 999 inclusive. Node numbers can be assigned arbitrarily within this range.

When a new node is added to the FIS (item # 5.1.1), its number is automatically assigned in ascending order. Node numbers can be changed at any FIS development stage. Point the mouse to the node and right-click. Near the chosen node a pop-up menu appears, shown in Fig. 11. This menu includes an option <Change Node Number>. Near the chosen node a number editing box appears (Fig. 13).

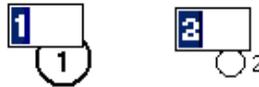


Fig. 13. Node Number Editing Box

Input a new node number in the editing box using the numeric keys. Then click the Enter key, if the node number has not been used, the node number changes, and the editing box closes. If a node exists with this number the number is not changed and a warning message is displayed (Fig. 14).



Fig. 14. Warning message box

When this warning message box is closed, the node number editing box re-appears (Fig. 13). Input a new node number and click the Enter key. This process repeats until a unique node number is input.



5.2. Connection Arrows

5.2.1. Adding Connection Arrows

To add an Arrow connecting two nodes in the FIS, click  on the shortcut toolbar (Fig. 2, Table 3). This button is fixed and Arrow Mode is set. Then choose graph's initial node (arrow starting point), point to it, and left-click the mouse. Holding the left button, drag the mouse to the terminal node (arrow end point), then release the button. The nodes are connected by a dotted line (future arrow) and an arrow type selection box appears (Fig. 15.a).

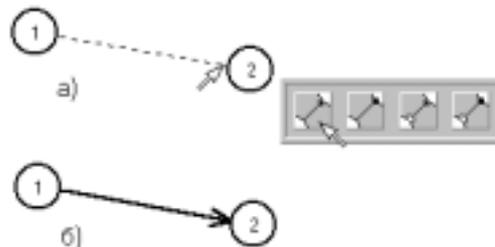


Fig. 15. Example of the FIS arrow input

Select the arrow type, point to the corresponding button, and click the mouse. The arrow of the chosen type will appear between nodes (Fig. 15.b).

5.2.2. Deleting FIS's Nodes And Arrows

To delete a node or an arrow click  on the shortcut toolbar (Fig. 2, Table 3). The button gets fixed. Then point to the arrow or node that is to be deleted, and left-click the mouse. The deletion confirmation dialog box is displayed (Fig. 16).

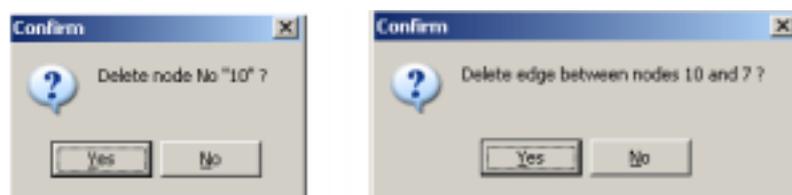


Fig. 16. Node / Arrow deletion confirmation dialog boxes

Click YES to delete the selected node / arrow. Click No to cancel deletion operation.



5.2.3. Relocating FIS's Nodes And Arrows

All nodes can be moved to any other location within the FIS input box. Click  on the shortcut toolbar (Fig. 2). The button gets fixed and the Selection Mode is set. Point to the node that is to be relocated, and left-click the mouse. Then holding the left button, drag the node to the desired location. Release the button, the node is fixed. All incoming and outgoing arrows of this node are automatically redrawn.

5.3. Explanatory Text

Explanatory text objects are used to input titles, comments, names, etc.

5.3.1. Text Input

To input explanatory text into the FIS, left-click  on the shortcut toolbar (Fig. 2). The button gets fixed and the Text Mode is set. Moving the cursor within the FIS input box, select the text input location and left-click the mouse. Text input dialog box is displayed (Fig. 17).



Fig. 17. Explanatory text input and editing dialog box

5.3.2. Selecting Text Font

To select explanatory text's font type, size, and color, use the Input and editing box's control buttons . Click  to open standard Font setting dialog box (Fig. 18). The Font box contains all explanatory text's font type, size, and color settings.

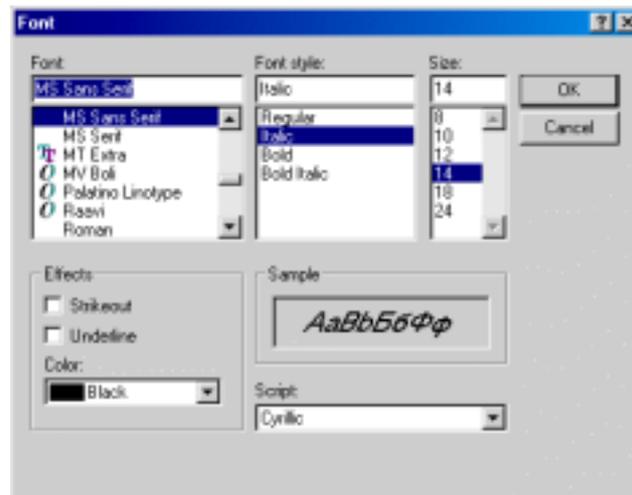


Fig. 18. Standard Font setting dialog box

The next three control buttons    are used for the quick font style setup – bold, italic, and underlined types correspondingly.

Click OK in the Input and editing box to set the new font type (Fig. 17). The font type can be set at any time, i.e. before, during, and after the explanatory text input.

5.3.3. Editing Text

5.3.3.1. Adding & Editing Text

Text is added using the keyboard (Fig. 17). The Software's text input functions correspond to the text editor functions (input, deletion, buffer copying, multiline editing). Example of title and explanatory text input into the FIS working box is shown in Fig. 19.

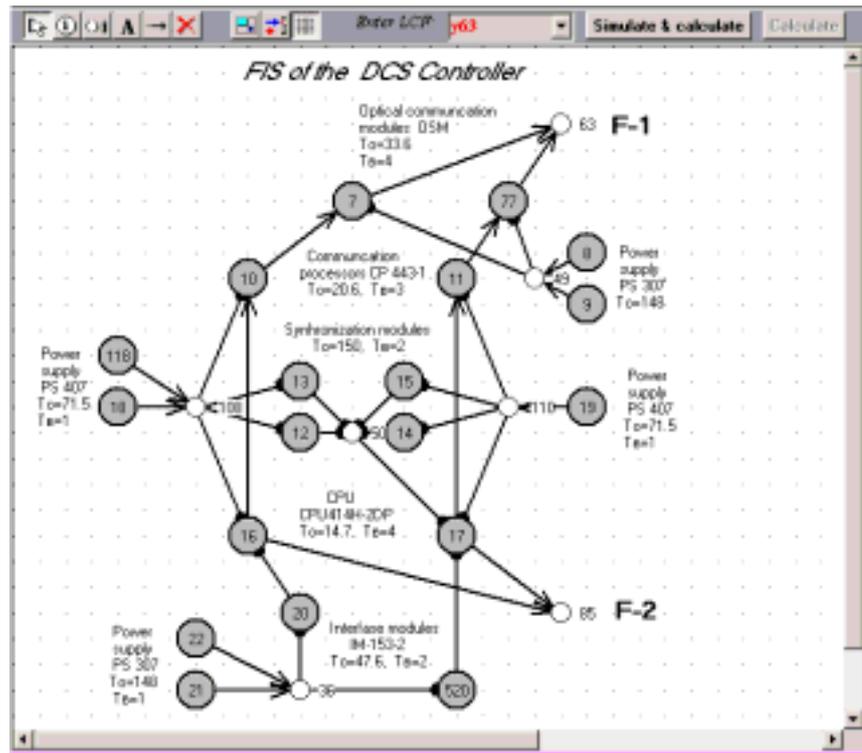


Fig. 19. Example of text input into the FIS working box

When the control button  is fixed (Fig. 17), the previously saved text will be displayed in the new created editing window. This text can be edited and added to the new FIS input box. When the control button is switched off, the previously saved text will not be displayed.

To edit the text that has already been added to the FIS input box, point to the text and right-click the mouse. Context menu is displayed (Fig. 20).



Fig. 20. Text context menu

Click the option Change Text to open the Input and editing box with the selected text (Fig. 17). Edit the text, then click OK to save changes in the FIS input box.

5.3.3.2. Deleting Text

Explanatory text deletion is similar to the FIS's node and arrow deletion (item # 5.5.2). Click  on the shortcut toolbar (Fig. 2, Table 3). The button is fixed. Then point to the text



segment that is to be deleted, and left-click the mouse. Deletion confirmation dialog box is displayed (Fig. 21).



Fig. 21. Text deletion confirmation dialog box

Click YES to delete the text. Click NO to cancel the deletion operation.

5.3.3.3. Relocating Text

Separate text can be moved to any location within the FIS input working box. Click  on the shortcut toolbar (Fig. 2). The button gets fixed, and Selection Mode is set. Point to the text that is to be relocated, left-click the mouse. Holding the left button, drag the mouse cursor. While moving, the text is shown as a rectangle. Release the button to relocate and fix the text.

5.4. Equivalented Nodes

Each function node of the FIS's main graph (developed in the main FIS input box) can become equivalented. Equivalented node means that the given node is a subsystem, which structure is represented in the FIS subgraph. These FIS subgraphs are developed in the specialized Software's window.

5.4.1. Specifying Equivalented Nodes In The Main FIS

Select the function node within the FIS input working box that is to be equivalented. Click  on the shortcut toolbar (Fig. 2). Node Mode of the main FIS graph is set. Then point to the selected function node, left double-click the mouse. Confirmation request is displayed (Fig. 22).

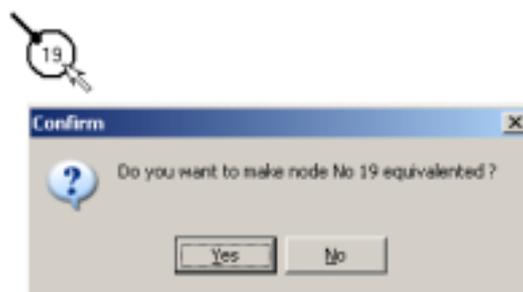


Fig. 22. Equivalented node input confirmation box



Click YES to input the equivalented node. The input box of equivalented node's FIS subgraph is displayed in (Fig. 23).

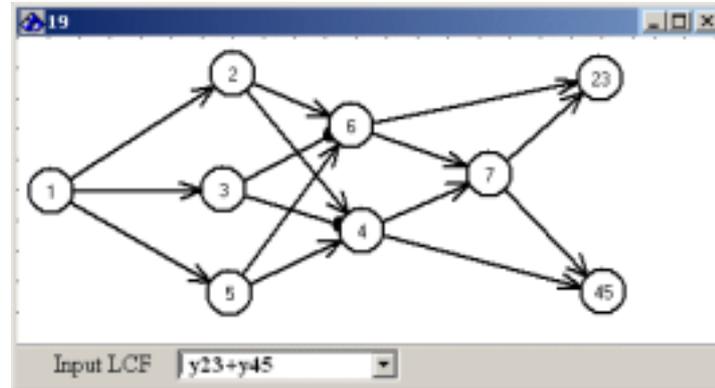


Fig. 23. The equivalented node's FIS subgraph input box

The window consists of the following three segments:

- Title bar located at the top of the window. Title bar contains the main FIS graph equivalented node's number;
- FIS subgraph input and editing field located in the middle of the window;
- Subgraph's LCF input field located at the bottom of the window.

Function and dummy nodes, arrows & explanatory text are added to the subgraph's input and editing field in the same way as into the main FIS graph. All operations are similar to those described above in items ## 5.1. – 5.3.

When the FIS subgraph development is completed, add the subsystem LCF to the LCF input field. Below are some guidelines for adding LCF subsystems:

- All LCFs are added in disjunctive normal form (i.e. not using round brackets);
- A capital Latin letter "y" should be added as a prefix to the integral function number, for example, "y23";
- If integral functions are added and they have conjunctive connection, they are written without spaces, for example, "y23y45". If there is a disjunctive connection, the disjunctive sign "+" is used, for example, "y23+y45" (Fig. 23);
- If it is necessary to add several LCFs at once, press the Enter key after each LCF input. Then the editing field is emptied, and the current LCF is fixed in the list. To view the LCF



list, click a down-arrow key, located to the right of the LCF editing box. The SW performs simulation based on LCF listed in the editing box.

When the FIS subgraph and LCF input are completed, left-click the button  in the corner of the top right hand window. The FIS subgraph input box closes. If the subgraph's LCF is not added before closing the window, a warning message will appear (Fig. 24).



Fig. 24. Warning message box

When the subgraph input box is closed, the equivalented node in the main FIS graph will be circled twice (Fig. 25).



Fig. 25. Equivalented Node View In The FIS's Main Graph

When the equivalented node is added, the user can view and edit the node's subgraph. To set the Node Mode (click  on the shortcut toolbar), point to the equivalented node and double-click. The FIS input and editing field will be displayed (Fig. 23). Then the FIS subgraph can be edited.

5.4.2. Deleting Equivalented Nodes

To delete an equivalented node:

- Click  on the shortcut toolbar;
- Point to the equivalented node and left-click the mouse. A confirmation request is displayed (Fig. 26).

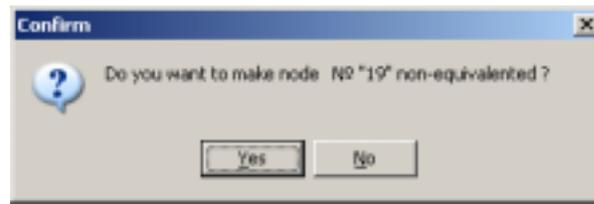


Fig. 26. Equivalented Node deletion confirmation request

- Click YES to replace the equivalented node with the main FIS graph's function node;
- Click No to leave the equivalented node unchanged.



Chapter III. PARAMETER AND MODE INPUT

6. Adding & Editing Element Parameters

The Software has two ways to input and edit element parameters.

1. Element parameters input line.

Point to the FIS's function node and right-click the mouse. The context menu is displayed (Fig. 11, on the left). Select Parameter Input option. A window shown in Fig. 27 appears.



Fig. 27. Element parameters input line

2. Element parameters input table.

The same parameters can be added using the table located at the bottom of the Parameter and Mode input window (Fig. 2). This Table is represented in Fig. 28.

Number of elements in all schemas = 18 Number of vertex in all schemas = 25

i	Pi	Tf	Tr	GIE	DE	Law	Toi	Multiple	Name
7	0	33.6	-1	0	0	1	-1	0	Optical communication modules OSM
8	0	148	-1	0	0	1	-1	0	Power supply PS 307
9	0	148	-1	0	0	1	-1	0	Power supply PS 307
10	0	20.6	-1	0	0	1	-1	0	Communication processors CP 443-1
11	0	20.6	-1	0	0	1	-1	0	Communication processors CP 443-1
12	0	150	-1	0	0	1	-1	0	Synchronization modules
13	0	150	-1	0	0	1	-1	0	Synchronization modules

Fig. 28. Element Parameters input table.

If the Table is hidden, access it using Main Window's scroll bars (Fig. 2).

The separate line (Fig. 27) is structurally similar to table lines (Fig. 28). The following element parameters can be added:

- No.** – number of the FIS's i nodes, that represent the system's elements; equivalented group elements are represented by means of composite numbers: 1^{st} – equivalented element numbers in the main FIS, 2^{nd} – element numbers in the equivalented FIS subgraph;



Pi – static probability of the binary event result, represented in the FIS by the *i* node;

Tfi – *i* element's mean-time-between-failures (years);

Tri – *i* element's mean restoration time (hours); code "-1" means that the *i* element is unrecoverable;

GIE – number of group of incompatible events, to which *i* element belongs; code "0" means that *i* element is independent, i.e. does not belong to any GIE;

DE– duplication parameter, equal to the number of the *i* element represented in the FIS by several duplicating nodes; code "0" means that *i* element is unduplicated;

Law – two codes are used in the present SC ASLS SZMA version:

"0" – static probability values ("Pi" column) are used in calculations;

"1" – exponential law of distribution of the *i* element non-failure operation time is used with "Tfi" & "Tri" parameters in calculations;

Toi – *i* element's proper non-failure operating time (hours); code "-1" means that *i* element non-failure operating time is considered to be equal to the whole system non-failure operating time;

Multiple – *i* element's multiplicity factor:

"0" - means that *i* element has no multiplicity factor;

integer positive number "+n" - means that *i* element represents a subsystem, consisting of "n" equitype elements with set parameters, using the AND logic (conjunctive multiplicity);

integer negative number "-n" - means that *i* element is a subsystem, consisting of "n" equitype elements with set parameters, using the OR logic (disjunctive multiplicity);

Name – contains brief information about *i* element and binary event properties (the FIS nodes).

7. Simulation Modes Setting

Before simulation & computing startup it is necessary to set simulation modes. Simulation & computing options are located on the toolbar at the top of the Parameter and Mode input box (Fig. 2). The toolbar overall view is shown in Fig. 29.

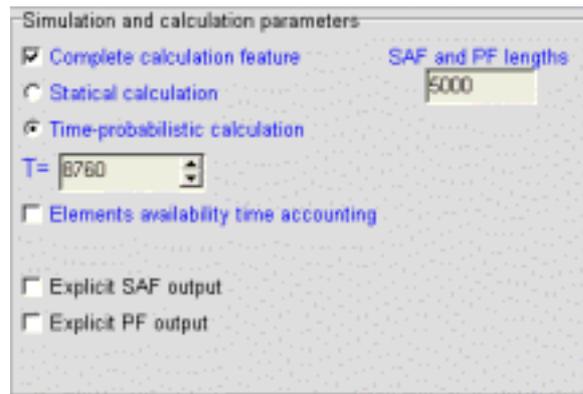


Fig. 29. Simulation and computing parameters input box

The toolbar contains the following options:

- Complete Calculation Feature Option: The Software constructs mathematical models, performs system reliability and safety computing (static probability of the non-failure operation probability criterion or availability ratio). When this option is selected (checked) the Software also determines: all elements significances and contributions, mean-time-between-failures and system mean restoration time;
- "Static calculation" and "Time-probabilistic calculation" (mutually exclusive) options:
 - When (Static Calculation) is selected, calculations are made based on Pi parameters – set static probability of binary events results that are represented in the FIS by function nodes. System non-failure operating time distribution diagrams are not drawn. The system operating time input box "T=" and "Elements availability time accounting" switch become invisible.
 - When the Time-probabilistic calculation option is selected, calculations are made based on Tfi, Tri parameters, set non-failure operating time, and other time characteristics. System non-failure operating time distribution diagrams are drawn;
 - The system non-failure operating time input box "T=" (hours). The default value is 8760 hours (1 year non-failure operation). When the "Static calculation" option is selected (see above), this box is not visible;
 - Elements availability time accounting option: When this option is selected, the set element's proper operating time Tri (less than system operating time in the "T="



box) is taken into account for time-probabilistic calculations. When not selected (check box cleared), proper element's operating time is not taken into account.

NOTE: This option is only available when Time-Probabilistic Calculation is selected. It is not available if "Static calculation" is selected;

- Explicit SAF output option: When selected the system's availability function (SAF) will be saved in the RezAcm.lst results file in its normal disjunctive form (list of shortest paths of the successful functionality, minimal cuts of failures and their combinations). When not selected the explicit logic SAF is not written in the results file, but only its size (conjunctions quantity);
- Explicit PF output option: When selected the system's probability function (PF) will be saved in the RezAcm.lst results file in the polynomial form. When not selected the explicit PF is not written in the results file, but only its size (monomials quantity);
- The "SAF and PF size" box is used to set maximum allowed SAF and PF size (quantity of SAF conjunctions and PF monomials). The default value is 5000.



Chapter IV. RESULTS SIMULATION AND VIEWING

7. Adding and Editing System LCF

LCF is added to the editing box “Enter LCF” located in the shortcut toolbar (Fig. 2). The system’s LCF input and editing field is shown in Fig. 30.



Fig. 30. LCF input box

Below are some guiding principles of the LCF input operation:

- A capital Latin letter “y” should be added as a prefix to the integral function number, making part of the LCF, for example, "y63";
- If multiple integral functions are added in the LCF with a conjunctive connection, they are added without a space, for example, "y63y85". If there is a disjunctive connection, the disjunctive sign “+” is used, for example, "y63+y85";
- If it is necessary to input multiple LCFs at once, press Enter key after each LCF input. The editing field is emptied, and the current LCF is fixed in the list. Then add the next LCF and fix it in the list. To view the LCF list, click a down-arrow key (Fig. 31). It is important to remember that the SW performs simulation and calculation based on the LCF listed in the LCF editing box;



Fig. 31. LCF list viewing

- If an integral function number is used for the LCF that does not correspond to any main FIS node, an Incorrect LCF Error Message (Fig. 32) is generated after pressing “Simulation and Computing” (Fig. 2).



Fig. 32. Incorrect LCF Error Message

8. Automated Simulation And Computing

8.1. Simulation Startup

Before starting automated simulation and computing of the system's reliability & safety measures, it is necessary to input the FIS, element parameters, system LCF and to set simulation modes. To start simulation, press the button "Simulation and Computing" on the shortcut toolbar (Fig. 2). During simulation process, the Software first performs automated logic SAF (system availability function) development (the set LCF realization). Process of logic simulation can be tracked based on the value change of the SAF's conjunctions quantity meter (Fig. 33), located at the top of the Simulation and Computing results output box (Fig. 2).



Fig. 33. Developed module size meter and total simulation & computing time meter

When the logic SAF development process is complete, the PF's polynomial development starts automatically. The PF size is displayed in the PF's monomials quantity meter box (Fig. 2, Fig. 33). The simulation process is completed when the SAF and PF meter values stop changing. The system reliability & safety measures are then computed.

9. Viewing Simulation And Computing Results

Main simulation and computing results are displayed in the special results output box (Fig. 2). To view all available information, maximize the box.

The simulation and computing results output box will display the following information:



- SAF and PF size displayed in the corresponding meter boxes (Fig. 33);
- System-wide reliability & safety measures displayed at the top of the simulation & computing results output box;
- The list “Diagrams” that displays output boxes of element significances, positive & negative contributions diagrams and output boxes of the system’s reliability time-probabilistic characteristics graphs;
- The list “Report” that displays the text of the RezAcm.lst file (automated simulation & computing results file).

9.1. Viewing Element Significances & Contributions Diagrams

Overall view of the output box of significances & contributions diagrams is shown in Fig. 34. Element positive contributions diagram is by default displayed first. To view other diagrams click the corresponding diagram viewing control button.

Low cut value (Fig. 34) is a minimum absolute value of the element’s significance/contribution to be displayed in the diagram. This helps to exclude non-significant columns and make the diagram more informative.

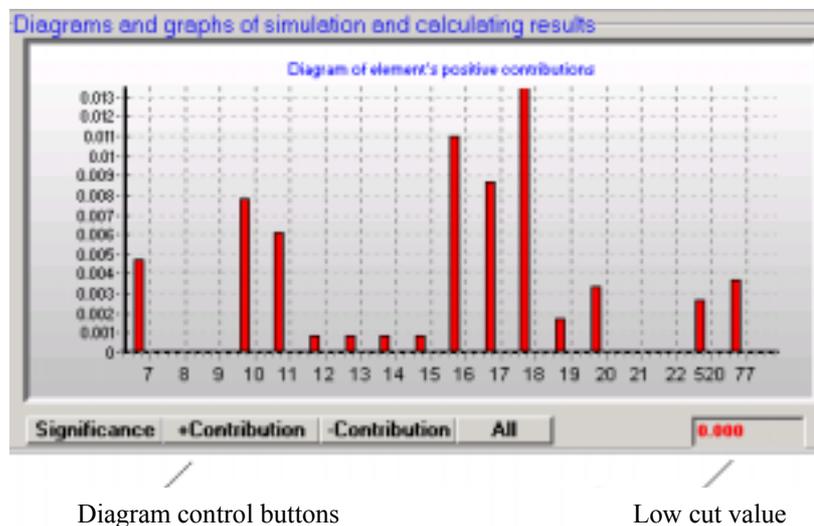


Fig. 34. Element positive contributions diagram

Significance & contribution diagrams are only displayed when the “Complete calculation feature” option is selected (Fig. 29).



9.2. Viewing Probabilistic And Time Characteristic Curve

Overall view of the time-probabilistic graphs output box is shown in Fig. 35.



Fig. 35. The system non-failure operation probability graph

Depending on the set computing mode, the following graphs are displayed in the output box: unreparable system's non-failure operation probability graph, repairable system's readiness function & first failure probability function graphs, and mixed system readiness graph.

9.3. Viewing Simulation And Computing Results Report

To view the automated simulation & computing results file RezAcm.lst select the list "Report" at the top of the results box (Fig. 2). The report text is displayed. Example of such text is shown in Fig. 36.

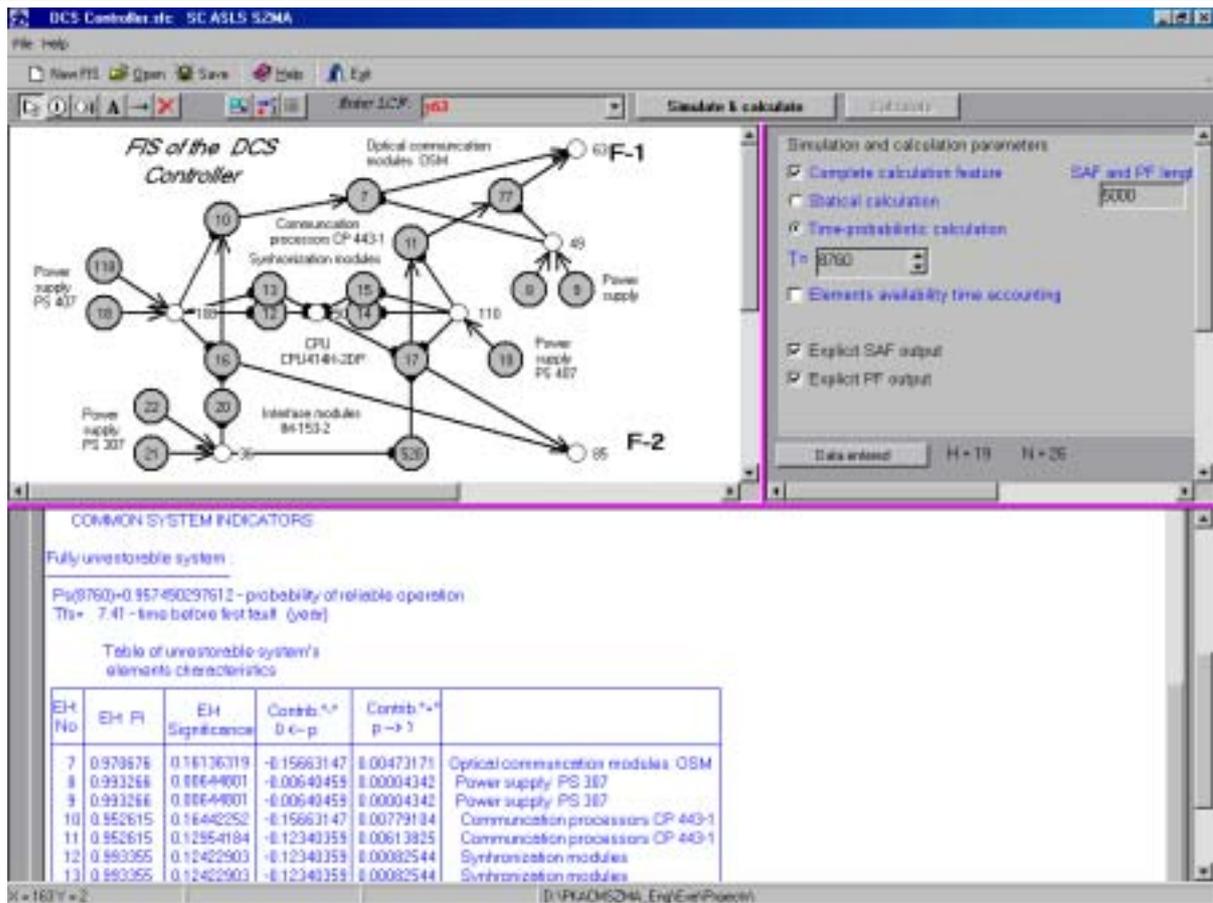


Fig. 36. Example of the simulation results text report

For large-scale simulation tasks the results file may not fit the report box size. The RezACM.lst file can be viewed and worked with using another text editor outside of the SC ASLS SZMA environment.



Chapter V. EXAMPLE OF THE SC ASLS SZMA SOFTWARE

As an example, let us consider the main operations of the SC ASLS SZMA preparation and software for the automated simulation and computing of a Filling Operation system's risk & safety measures. This Filling Operation system's measures are described in RD 03-418-01 Instructions, the Risk Analysis Performance For Hazardous Industrial Sites, issued by GOSTECHNADZOR of The Russian Federation.

10. Preparatory Phase

The following initial data are specified in [RD 03-418-01] :

- Description of the Filing Operation's Fault-tree;
- Set probabilities of initial events.

This data is shown in Fig. 37 and Table 4.

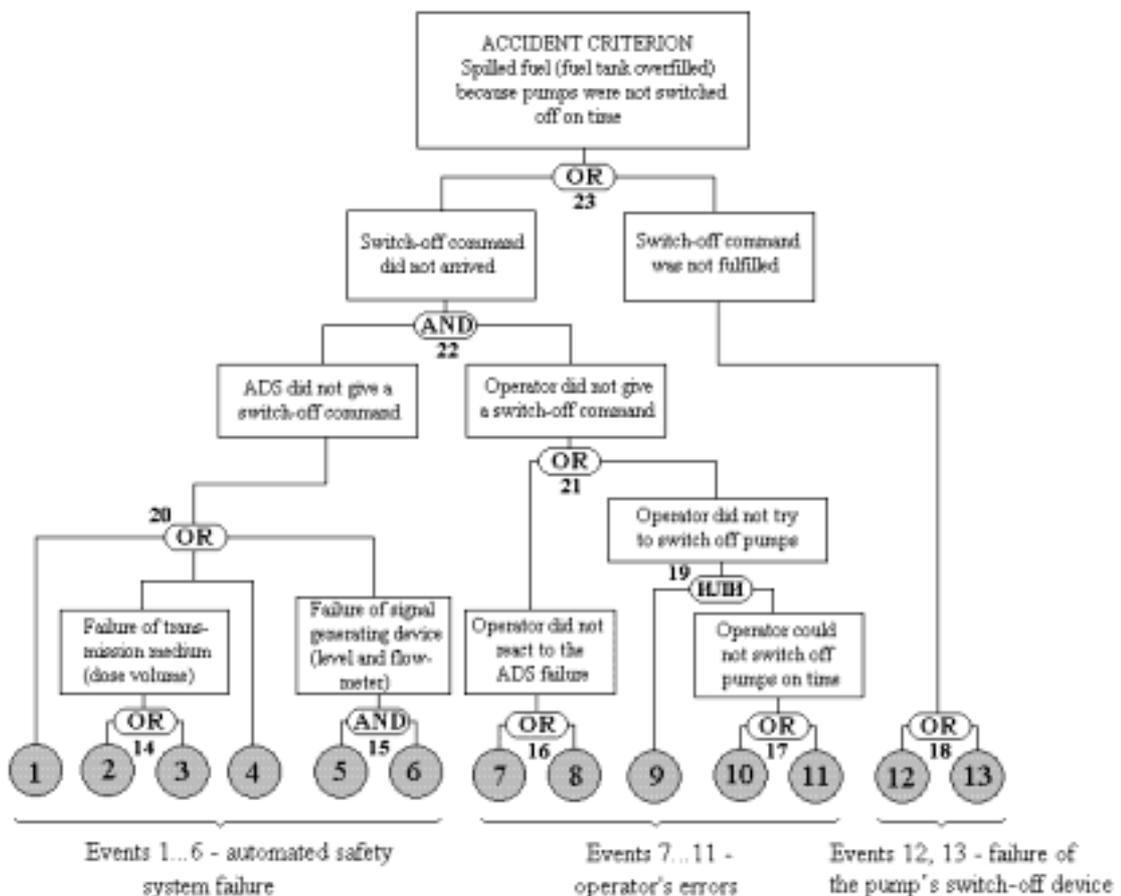


Fig. 37. Filling Operation Fault-tree



Table 4

No. <i>i</i>	Filling Operation, failure tree, initial events	Probability <i>P_i</i>
1	Automated dosing system (ADS) was off	0,0005
2	Failure of signal transmission circuit from dose volume sensors	0,00001
3	Dosing signal depression due to noise	0,0001
4	Failure of dosing signal transducer amplifier	0,0002
5	Flowmeter failure	0,0003
6	Level sensor failure	0,0002
7	Operator did not notice the light indication of the ADS failure	0,005
8	Operator did not hear the audible alarm of the ADS failure	0,001
9	Operator did not know about the necessity to turn off pumps after the time period's expiration	0,001
10	Operator did not notice the chronometer indication about the filling time period's expiration	0,004
11	Chronometer failure	0,00001
12	Failure of the automated switch of the pump's electric drive	0,00001
13	Failure of the pump drive control circuit	0,00001

For the SC ASLS SZMA software based on the fault-tree (Fig. 37), the filling operation system's FIS is created (Fig. 38).

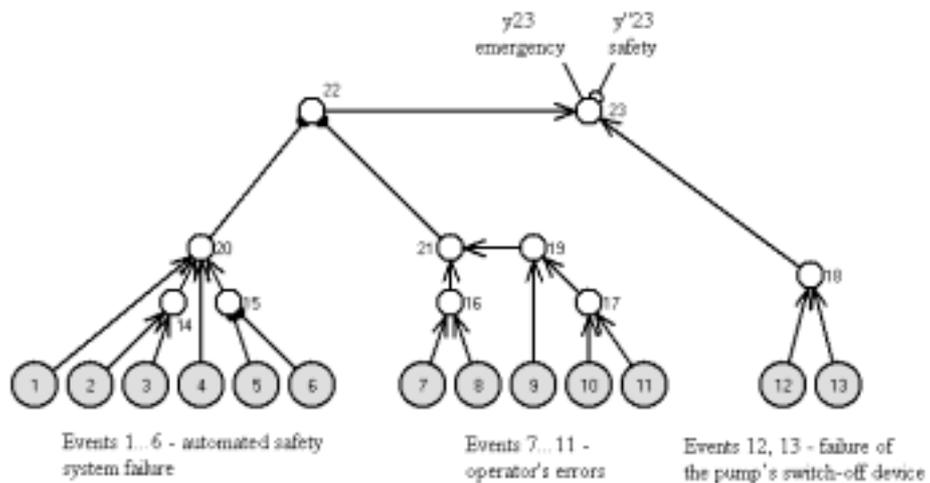


Fig. 38. Filling Operation failure FIS

The FIS in Fig. 38 is similar to the fault-tree shown in Fig. 37. The only external difference is in the replacement of the fault-tree's logical connectives (AND, OR) (Fig. 37, ## 14-23) by the FIS dummy nodes with the same numbers, conjunctive & disjunctive ingoing arrows (Fig. 38).

To calculate the filling operation failure probability, a logic criterion of failure occurrence is specified: $Y_{failure} = y_{23}$



Probability parameters of elements' reliability and initial events instance are shown in Table 4. Thus all initial data required for the SC ASLS SZMA software are prepared.

11. The SC ASLS SZMA Start-up and Initial Data Input

At this stage the following operations are performed (Fig. 1, Fig. 2):

1. Click the icon (Fig. 1) to start the SC ASLS SZMA;
2. Click the button "New FIS" (Fig. 2) to open the new FIS input field;
3. In the FIS input field a FIS graph is created (Fig. 39);
4. In the Pi column of the Parameters Table located in the Parameters and modes input box, the filling operation events probabilities as shown in Table 4, column #3;
5. On the simulation and computing parameters input bar (Fig. 29) the following options should be selected:
 - Static calculation
 - Explicit SAF input
 - Explicit PF output

When these operations are completed, the SC ASLS SZMA main window looks as shown in Fig. 39.

12. Viewing Simulation and Results

When the initial data for the Filling Operation has been prepared and inputted, the SC ASLS SZMA automated logic structural simulation and computing are started using the "Simulation and Computing" button on the shortcut toolbar (Fig. 2, Fig. 39). All other operations, such as logic and probabilistic functions development, computing, results displaying and saving in the file RezAcm.lst, are performed automatically.

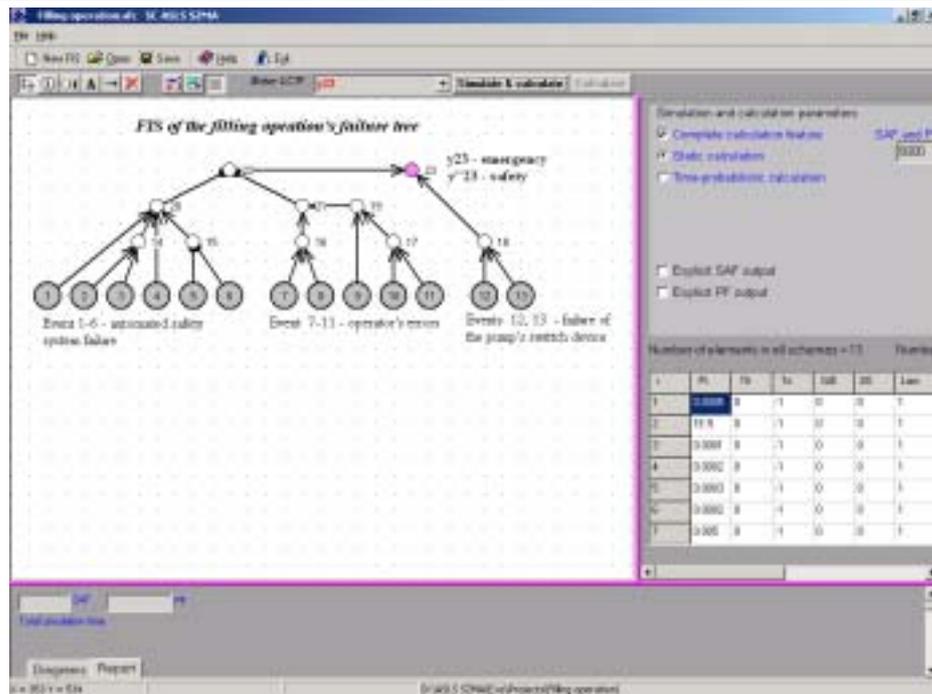


Fig. 39. Initial data and simulation modes input

When simulation and computing process is completed, the results are displayed in the Simulation and computing results output box (Fig. 40).

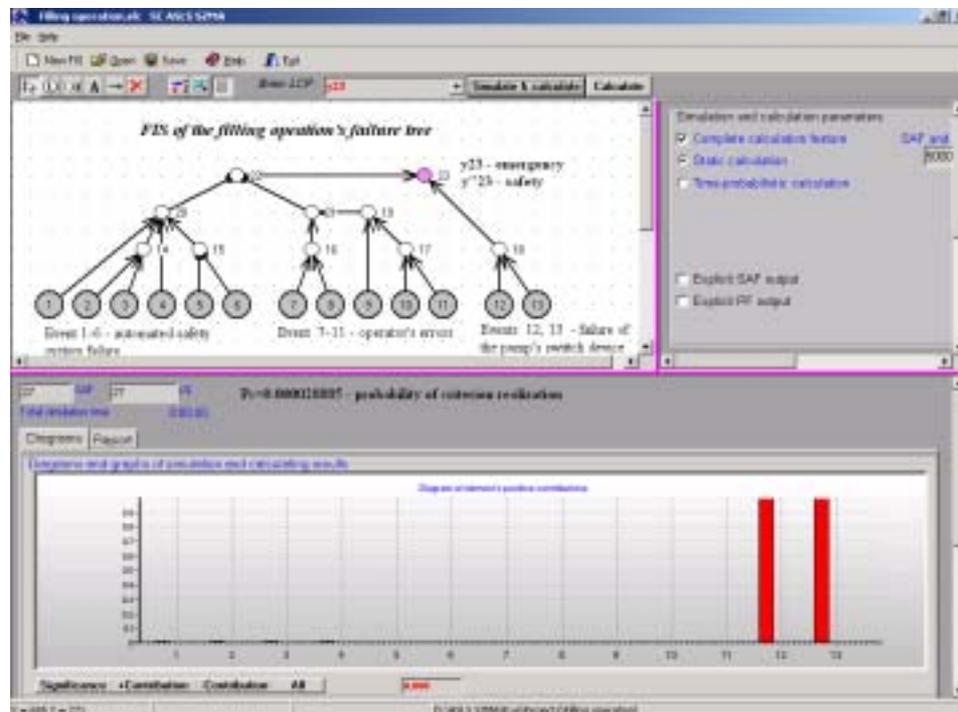


Fig. 40. Automated simulation and computing results



As a result the following safety measures of the given filling operation were received:

1. Failure occurrence probability is 0.0000297;
2. The significance diagram shows that the most critical elements are #12 & 13 of the pump control subsystem;
3. Number of elements' minimal failure cuts (minimal combinations) is 27 combinations;
4. Size of the PF polynomial developed in the SC ASLS SZMA is 27 items.

Logic SAF and PF polynomial can be viewed in their explicit form using the list "Report".

Fragment of the Report text with PF's polynomial listing as shown in Fig. 41.

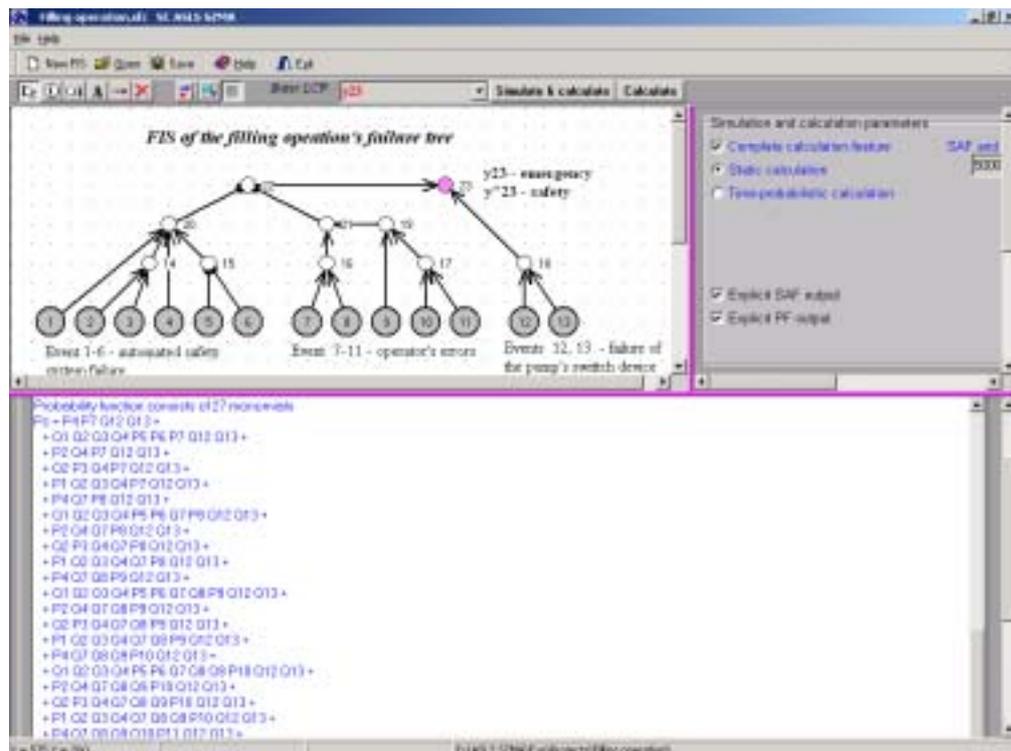


Fig. 41. Fragment of the probabilistic simulation results report

The report contains full information about logic and probabilistic models generation results and calculations of the system/equivalented subsystem reliability & safety probability rates.



The SC ASLS SZMA development environment:

1. Microsoft Windows XP Professional, Version 5.1(Build 2600.xpcp 1.020828-1920: Service Pack 1), Copyright © 1981-2001 Microsoft Corporation, CD SET: X08-40893;
2. Programming system Borland Delphi Professional, Version 7.0 (Build 4.453), Copyright © 1983-2002, Borland Software Corporation, Registration Key: 9617613;
3. Software prototype SC ASLS - 2001 [4], Certificate of official registration of computer program No. 2003611099, dated May 12, 2003, issued by ROSPATENT of The Russian Federation;
4. LOG_WF.bpl library of program modules for automated generation of system availability monotonous and non-monotonous logic functions and probability function polynomials (Certificate of official registration of computer program No. 2003611100, dated May 12, 2003, issued by ROSPATENT of The Russian Federation), under contract with JSC SPIK SZMA No. 02-9/05, dated April 30, 2002.

The present SC ASLS SZMA has a Certificate of official registration of computer program No. 2003611101, dated May 12, 2003, issued by ROSPATENT of The Russian Federation.



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