Tutorial

Part 1 & 2

Version 6.2
April 2013

Simulations**D**ienstleistungs**Z**entrum GmbH
Hauert 20
44227 Dortmund
Tel.: (02 31) 97 50 50 - 0
Fax: (02 31) 97 50 50 - 50

This manual is part of the program
DOSIMIS-3 for MS-Windows
The names DOSIMIS-3 and MS-Windows are reserved.

© 1994-2013 SDZ GmbH
SimulationsDienstleistungsZentrum GmbH
Hauert 20
44227 Dortmund
Tel.: (02 31) 97 50 50 - 0
Fax: (02 31) 97 50 50 - 50
URL: www.sdz.de,
e-mail: Dosimis-3.support@sdz.de

All rights reserved. No part of this script shall be reproduced, stored in a retrieval system, or transmitted by any means, electronic, mechanical or otherwise, without written permission from SDZ GmbH.

0 Table of Contents

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

1 Introduction to the Tutorial (Part 1)

1.1 Structure of the Tutorial

Using simulation technology to answer logistic questions demands powerful simulation Tools, which are simple to use. DOSIMIS-3 measures up to both demands and therefore it is deployed in several ways in industry - simulation technology is nowadays moving towards education.

The educational version of DOSIMIS-3 contains a reduced scope of service regarding both the size of a simulation model and the supply of interfaces and modules to create extensive control logics. Information about the complete scope of service will be supplied on demand.

DOSIMIS-3 requires the operation system Windows 7/Vista or XP. For the version only the least configuration is presupposed of the used operating system (Windows 7 or Vista: 1-Gigahertz (GHz) processor with 1 GB RAM; XP: Pentium 300 und 128MB RAM). For working with the 3D component of Dosimis-3 a DirectX - graphics adapter is recommended. A free hard disk size of approx. 200 MB is recommended in order to examine smaller models without complications. Bigger models achieve however very soon a use of several a hundred megabyte hard disk size for the statistics. For the graphics a resolution of at least 1024x768 pixel is expected. However a resolution of 1280x1024 or higher is recommended.

This tutorial shall enable the user to create models himself, to edit values of parameters and to modify the model. Furthermore this tutorial acts as guide for designing a seminar of a training course in simulation, including the run of experiments using a predetermined model in chapter 4.

Chapter 2 will provide a short overview about the philosophy of creating a model, chapter 3 describes all steps from the creation of a model till the initial results. Furthermore a practical example will be illustrated.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

1.2 Installation of DOSIMIS-3

The installation of DOSIMIS-3-Windows is very simple.

Installation from CD:
Usually the installation is started automatically when the CD is inserted. If this does not happen, carry out the installation by starting the program Setup.exe from the Explorer. It can be found in the root directory of the CD.

Installation from floppy disk:
Insert the first floppy disk into the disk drive and start **Setup.exe**.

Installation from the internet:
Download the DOSIMIS-3 installation file from the Internet (www.sdz.de) and save the file on your hard disk. To start the installation of DOSIMIS-3, run this file by double-clicking it in Explorer for example.

Installation from an e-mail (one file):
Save the file from the attachment on your hard disk. Start this file by, for example, double-clicking it in Explorer to start the installation of DOSIMIS-3.

Installation from an e-mail (several files):
Save the files from the attachment into one directory on your hard disk. Start the program **Setup.exe**.

Start DOSIMIS-3 after the installation. The installation is then completed.

While installing with Windows 7 / Windows Vista / Windows XP you must have **administrative rights** so that the necessary entries can be made in the system files. Otherwise you may install only a demo version. Standard users are not permitted to make any entries in the general start menu, such that no icon for DOSIMIS-3 can be created.

After starting the setup, further queries may appear, in which basic settings usually have to be confirmed. During the first installation, it is recommended to carry out a full installation. Then start DOSIMIS-3 with administrative rights. The installation is then completed.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

2 Task

2.1 Philosophy of Modeling

Logistic systems can be analyzed very easy with the help of a simulation tool, if the tool offers the necessary elements to create a model. In DOSIMIS-3 this elements are

- ***modules*** and
- ***objects***.

The underlying object-oriented philosophy of modeling assumes that buffers and conveyor belts, work stations, reject gates will be represented by ***modules***, which reproduce the behavior of this elements within the required accuracy. A module in DOSIMIS-3 has a specified process logic, respective parameter records and predefined standard statistics.

Objects are used to describe movables like work pieces or palettes (even maybe information). They are marked by numbers, that identify an object type. A model is created in several steps:

- place modules in the DOSIMIS-3 window
- edit module parameters (data)
- connect the modules
- define parameters of simulation
- run the simulation
- look at the results either by watching the animated material (object) flow or see the result statistics.

Handling of objects is defined through the parameter-input mask. Every source contains information about the objects entering the system. All other modules have information on how to handle each object inside the module. In this manner, data input is possible in a clear and compact manner.

2.2 Exercises

The following example is taken from a project and it contains all features of a simulation study. The base for the model is the layout of a planned production hall. A lot of assumptions have been made that have to be checked by simulation.

2.2.1 Model

Consumer goods are produced on the production line of an electrical manufacturer. There is also a sub-area where the goods are inspected and where minor repairs can be carried out. The material flow is illustrated in Figure 2.1. A preliminary production area supplies our production line with two different kinds of product groups (randomly distributed) in intervals of one minute. Both kinds of goods enter the system at a receiving buffer and are fed to the two work stations by shuttle. But there is a fixed assignment of each kind of goods to the individual work station, because a full flexibility cannot be operated economically due to high investment needs.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Due to the processes being technologically difficult to control, a high quantity of rework is accumulated. The parts to be repaired are fed back to the work. Setup times of considerable importance arise in this case.

Layout of the production system

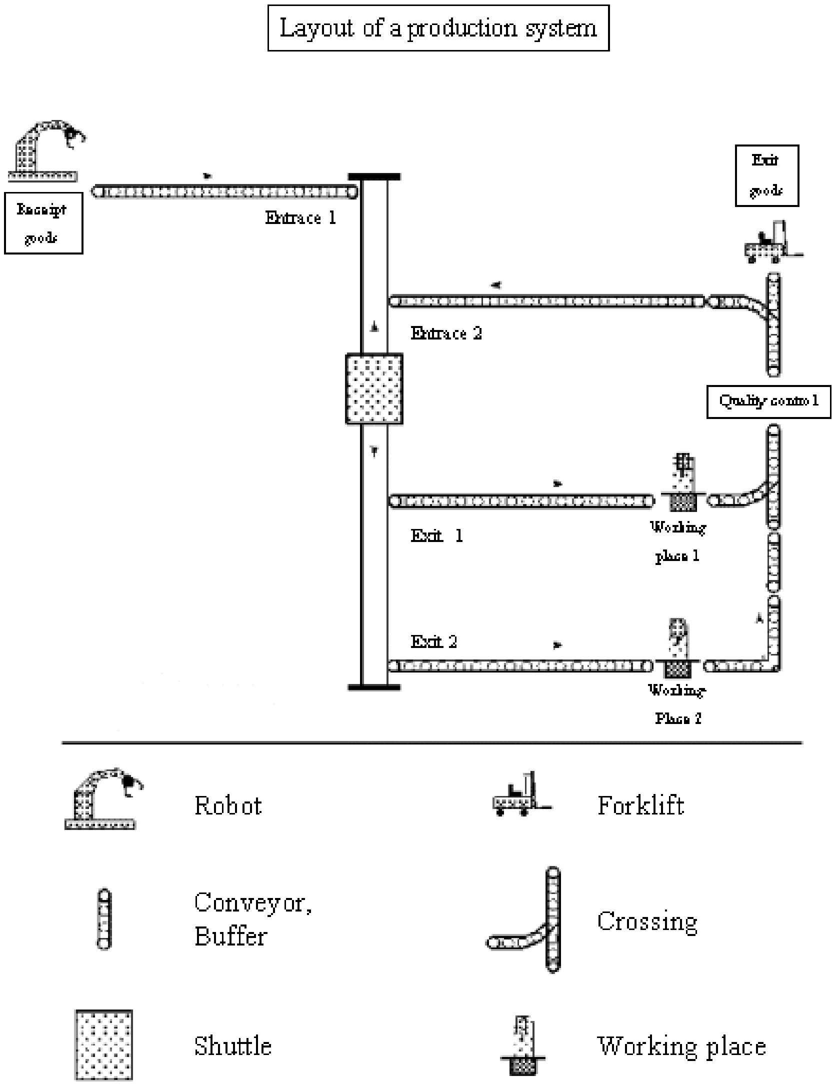


Figure 2.1.: Example of a practical application

2.2.2 Question

Following questions have to be answered:

- Is it possible to achieve the desired throughput of 60 parts per hour (on average)?
- Where are weak spots in the system?
- How high is the utilization of the work stations?
- How much is the utilization capacity of the shuttle?

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

- Does the mode of operation of the following production line have effects on the utilization of the work stations?

The questions are supposed to be examined under the assumption that failures of the conveying system do not matter. The employed machine operators are supposed to be constantly available. The usage of a standby-employee system may be necessary.

2.3 Database

Data showed that it is possible restrict our consideration to two kinds of products. The layout can be created in small steps. There is a definitive range of supplementary buffer space available. However, it is not possible to forge the use of the shuttle, because the receipt of goods and the two work stations are placed in two halls.

Following data were collected:

2.3.1 Source

The Source (SOU) is an interface that feeds products into the production area under consideration. Products of type 1 and 2 appear in random sequence. Both products are equally frequent. On average products arrive every 60 seconds (normally distributed with a variation of 5 seconds).

2.3.2 Accumulation Conveyor

The accumulation conveyor (BFS) is a conveyor and buffer element. Each accumulation conveyor has a velocity of 0.2 m/sec. The length of a component carrier is 1 m.

There is a different buffer capacity for each conveyor.

- 10 parts after the source,
- 2 parts before the work stations,
- behind work station 2 there is an edge conveyor and a buffer with a capacity of 4,
- 3 parts on the feedback conveyor (for rework).

2.3.3 Shuttle

The shuttle (SHU) is a transport element (vehicle) moving on rails. It picks up loads at a loading station and carries them to unloading stations by means of a vehicle. The loading distance for component carriers is 1.1 m, the unloading distance is 0.1 m, and the velocity for loading and unloading is 0.2 m/sec.
Velocities are specified as follows:

- Maximum speed: 1 m/sec
- average velocity to position: 0.1 m/sec

Following local controls are planned:

- Source has priority
- Product assignment to the exits.

2.3.4 Work Station

The work station (WST) allows reproduction of both manual and automatized working environments (for example robot). Work stations have a length of 1 m. Conveying speed to feed paletts into the station is 0.2 m/sec.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

The following intervals are planed:

- Processing time: 80 seconds normally distributed (standard deviation 5 seconds)
- Set-up time: 120 seconds total (necessary for rework)

Rate of rework is 15 %.

2.3.5 Combining Station

The combining station (COM) is used for reproduction of points that merge different material flows. The combining station is 1 m long and conveying speed is 0.2 m/sec.
A FIFO (first in first out) strategy is suggested.

2.3.6 Distributor

The Distributor (DIS) is used for reproduction of points that separate one material flow into several different flows. It contains the same conveying parameters as the combining station. The distribution strategy results from the destination of the product (sink or rework).

2.3.7 Sink

The sink (SIN) is an interface to the environment, where products leave the system and are delivered to further production areas. The average departure time at the sink is 55 seconds and exponentially distributed.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

3 Modeling of a Production System

3.1 Entry

If installed, you will find DOSIMIS-3 in the Program folder of the “Start” menu of your Windows desktop. Please select **Start/Programs/DOSIMIS-3** from your Windows desktop to start the simulation tool. This simulation tool was implemented according to MS-Windows conventions as much as possible - that is why this tutorial will contain additional remarks regarding handling of Windows.

The first step in creating a new simulation model is to select **File/New** from the menu bar. This opens a new window for the new model which is named “Dosimis-3-1” by default. You can change this name by saving the model with a new name if using the **Save as** option from the **File** menu. Please do not forget to save your model regulary.

The size of the man window of DOSIMIS-3 and of the model window (Dosimis-3-1) can be changed by using the window buttons “Maximize” or “Reduce” in the upper right corner of the window.

If smudges or incomplete pictures appear in your DOSIMIS-3 window, please use the “F5” button on your keyboard to refresh the screen.

As next step select **View/Modules palette** from the menu bar. A new window containing “arrows” and “symbols” subsequently appears. The arrows point in the direction of material flow (orientation) and the symbols represent the modules. Now there are two opened windows, with which the user has to work, the “*module window*” (small) and the *work area* named “Dosimis-3-1” (large) inside the main window of DOSIMIS-3.

To place the source (SOU) in the workspace window of your model, first select the orientation (right: ➔) on the module window and then click on the source symbol. (When pointing at a symbol with the mouse, the name of the module appears under the mouse pointer and a short description of the module is displayed in the status bar of the main window.) Now place the cursor at the designated point inside your workspace and press the right mouse button to release the source and to fix it on the workspace. The source is now selected and therefore its symbol is displayed in red color. The work area contains an invisible grid, so modules only can be placed depending on this grid. So if your action failed, please try again. If the wrong module or orientation has been chosen, then you have to delete the last entry. Please select the module if necessary (red symbol => selected), press the “Delete” button on your keyboard or select **Edit/Delete** from the menu bar and confirm this action by clicking the “OK” button of the dialog window that appears.

<u>Important:</u> There is a grid on the work area, which means that modules can be put on the work area only at fixed distances. If you want to move a module, then click the module, keep the mouse button pressed while moving and release the button when the module reaches its final position.

The next module to be placed in the model is an accumulation conveyor (ACC). The accumulation conveyor is placed similar to the source - but the ACC is a module with a variable shape - therefore act as follows: select the desired orientation and the ACC symbol on the modules palette, and then click the source in your model to fix the initial point of the ACC. Now place the mouse cursor a little bit right of the desired end point of the ACC and click the left mouse button to fix this point. After this, please click the right mouse button to leave the graphical edit mode of the ACC. As you have seen, the initial point of the ACC was placed a little bit right (two grid points) of the source you clicked on. In the same manner the end point has been placed (two grid points) left of your cursor. This behavior is to help you to place an ACC between two stations.

Now select the orientation down (🡻) and the shuttle (SHU) on the modules palette and place the initial point of it at the right end of the ACC. Now place the cursor about 5 grid points below the initial point and hit the left mouse button to fix the end point of the shuttle and to leave the graphical edit mode. The following modules are now placed in your work area. (Figure 3.1):

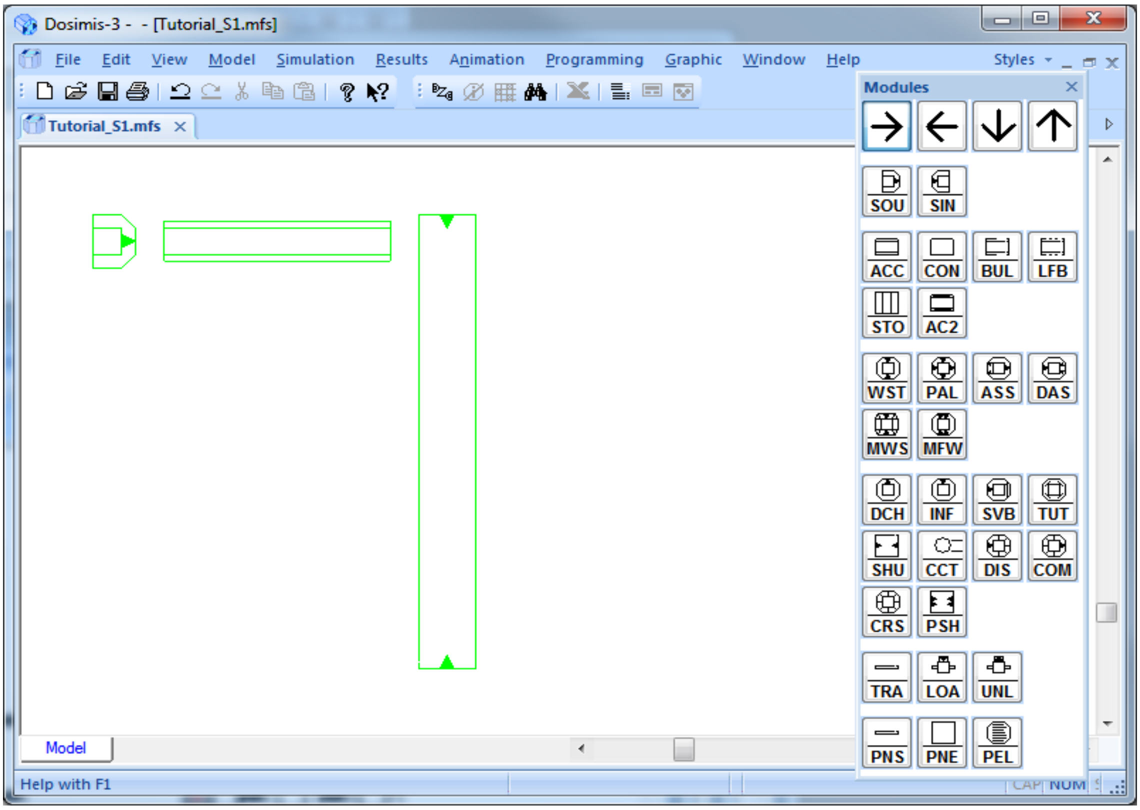


Figure 3.1: Placing the first modules

Other modules will be placed the same way:

- one accumulation conveyor (ACC) at the right side of the shuttle - close to the middle,
- one work station (WST) at the right end of this accumulation conveyor,
- one further accumulation conveyor (ACC) at the right side of the shuttle - close to its end point,
- one work station (WST) at the right end of this accumulation conveyor (below the first WST),
- to create the edge conveyor at the right side of work station 2, perform the following steps: select orientation right (➔) and the ACC module on the modules palette, then click with the left mouse button on WST 2, next place the cursor in the middle of the

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

green-colored ACC symbol in your model and press the left mouse button again, now place the cursor one grid point above and press first the left and second the right mouse button.

Now your model looks like figure 3.2:

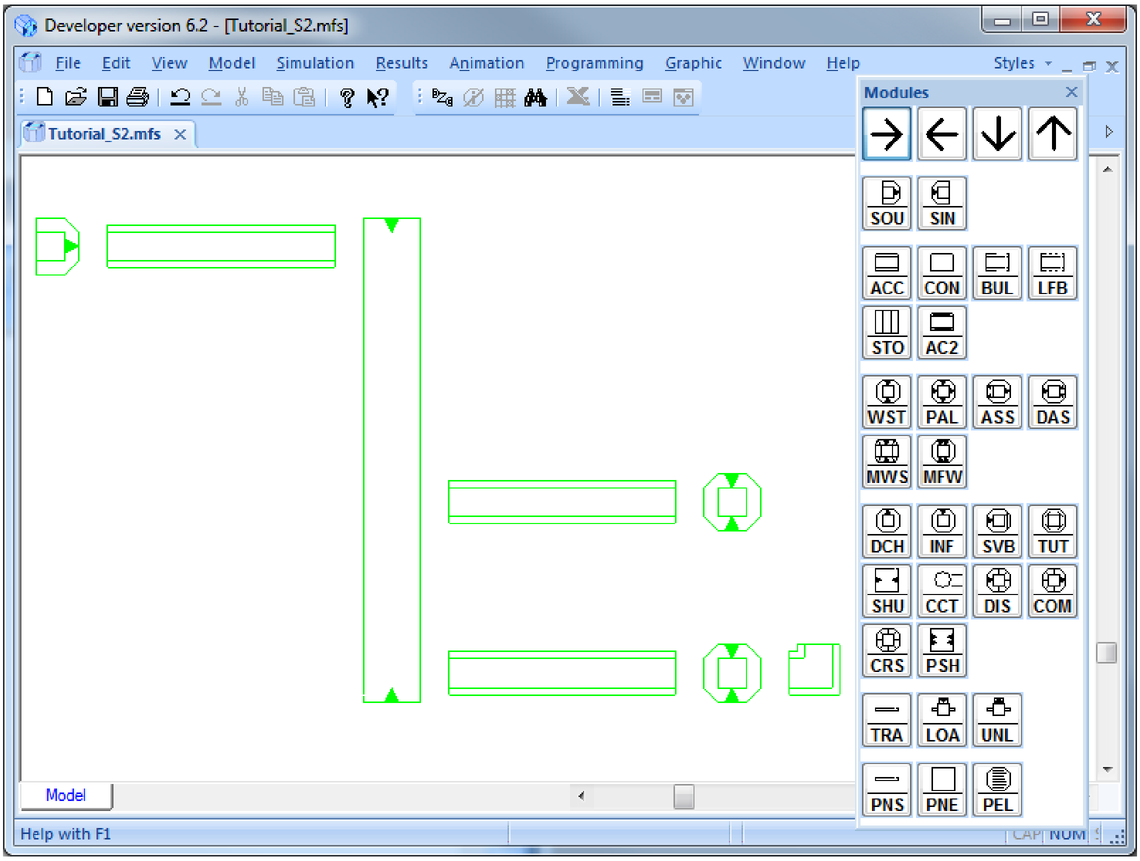


Figure 3.2: Placing of further modules

To optimize the view of your model, select **View/Zoom …/Model** from the menu bar of your DOSIMIS-3 window.

Before placing the next 4 modules, select orientation up (🠉) on the modules palette.

Then place the following modules one after the other into your model:

- Accumulation conveyor (ACC) (length: 1 grid element)
- Combining station (COM)
- Distributor (DIS) and
- Sink (SIN)

Now your work area should look like Figure 3.3

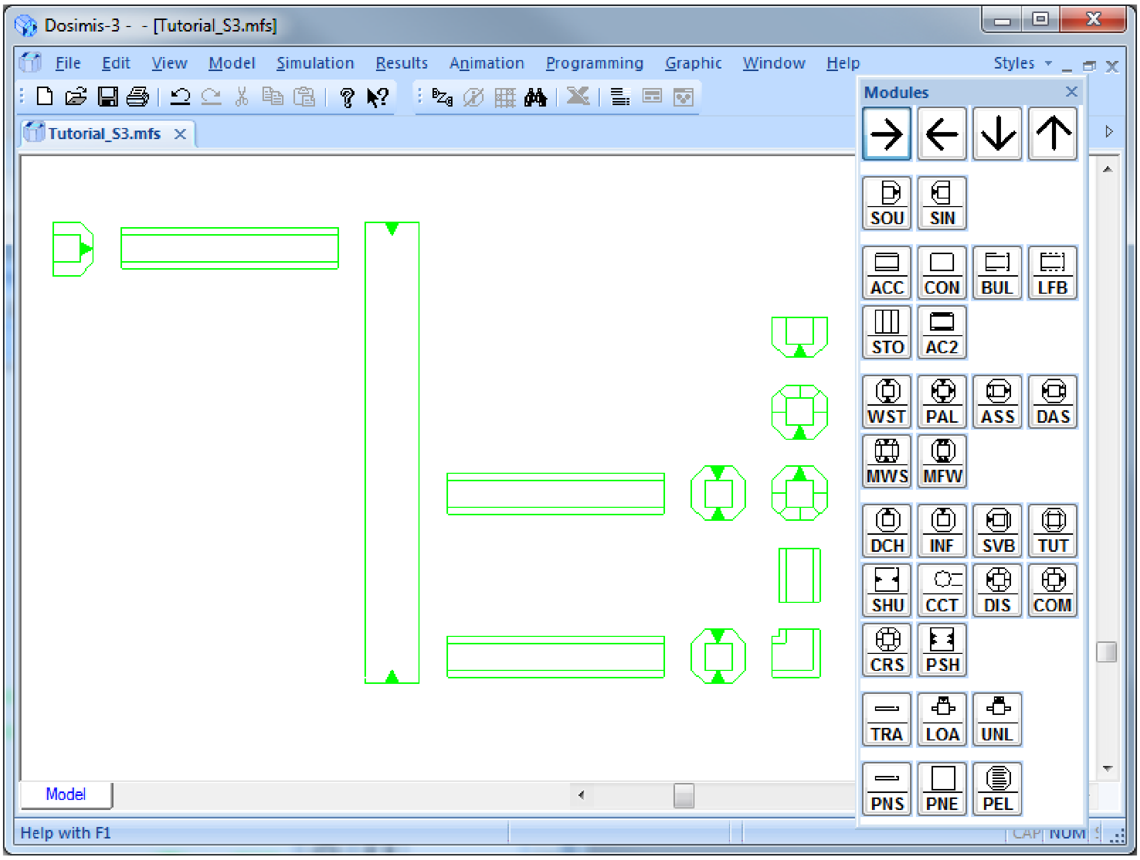


Figure 3.3: Placing of modules with orientation up

The last module to be placed (feed back) requires changing the orientation of material flow to left (🡐). Then select the ACC symbol on the modules palette and place the accumulation conveyor between the distributor and the shuttle. The final Figure (Figure 3.4) displays all necessary modules on your work area.

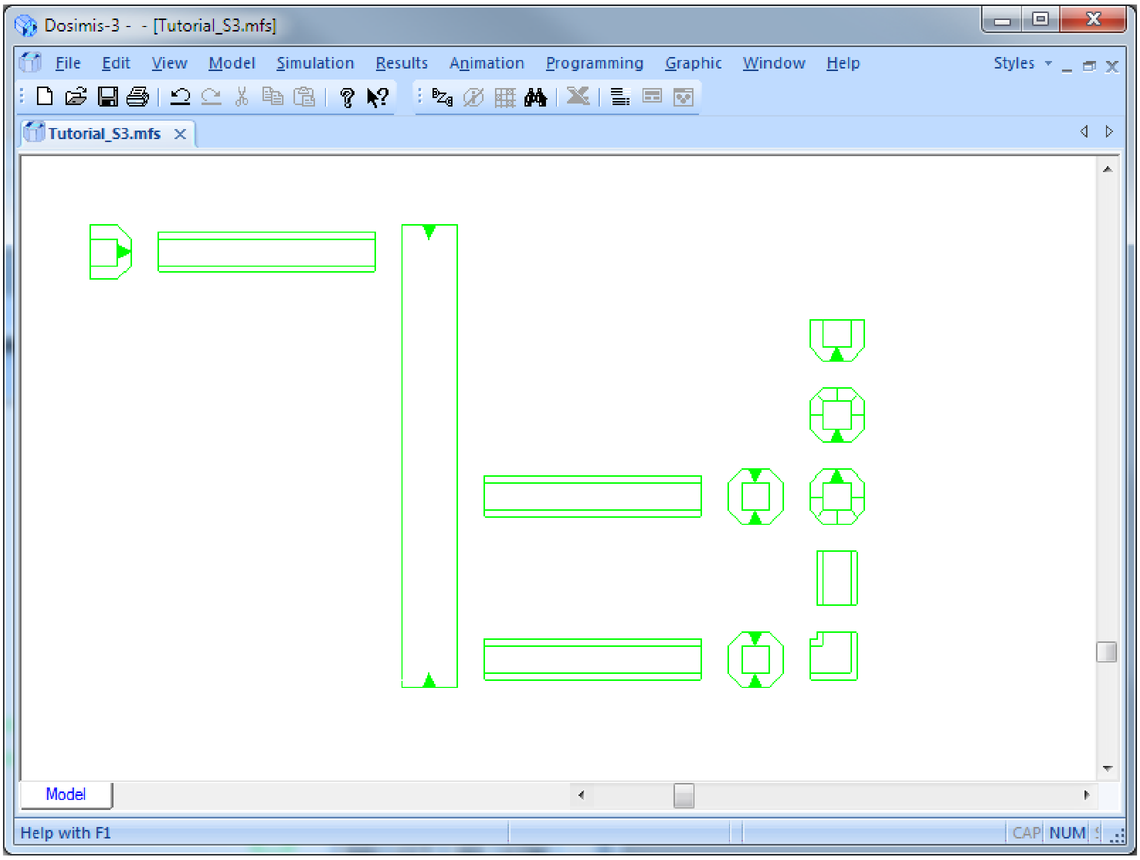


Figure 3.4: Layout containing all modules

Now you should save your model. Therefore select **File/Save as** from the menu bar of your DOSIMIS-3 window. A new window appears, where you can enter the filename for your model. Default is “Dosimis-3-1.mfs”. Change the filename to “Tutorial_S5.mfs” and click on the “Save” button.

3.1.1 Linking of Modules

Our next step will be to connect or to link the modules. Please select **Model/Linking active** from the menu bar. Now linking mode is active (displayed by a node symbol at the bottom of the mouse cursor) and you can enter links between the modules representing material flow connections. Therefore please click with the left mouse button on the start module, then select the destination module by click on the left mouse button and fix the link by pressing the right mouse button.

The fixed link is displayed as a line with two arrowheads. The display color of the start module (source) should have turned to black. The black color indicates that all necessary data entries for the module are done. Please repeat the procedure above until all entrances and exits of all modules are linked. But pay attention to the sequence of connecting entrances and exits and assigning the entrance/exit number to an entrance/exit!

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Important!

For modules with more than one entrance/exit the sequence of linking has an influence on parameter settings, because the sequence of connecting entrances/exits assigns the entrance/exit number to an entrance/exit! In our model this modules are: the shuttle, the combining station and the distributor.

Linking rule:

Entrance 1 is assigned to the first input link, entrance 2 is assigned to the second input link and so on. Same applies to the exits. In case of the shuttle that means: connect the receiving buffer to the shuttle first (entrance 1), connect the feed back conveyor afterwards (entrance 2). To link the exits, first connect the ACC above to the shuttle (exit 1) followed by the ACC below (exit 2).

Please link the distributor to the sink at first (exit 1) followed by the feed back conveyor (exit 2).

Now you have finished your model and the model window on your computer screen looks as follows:

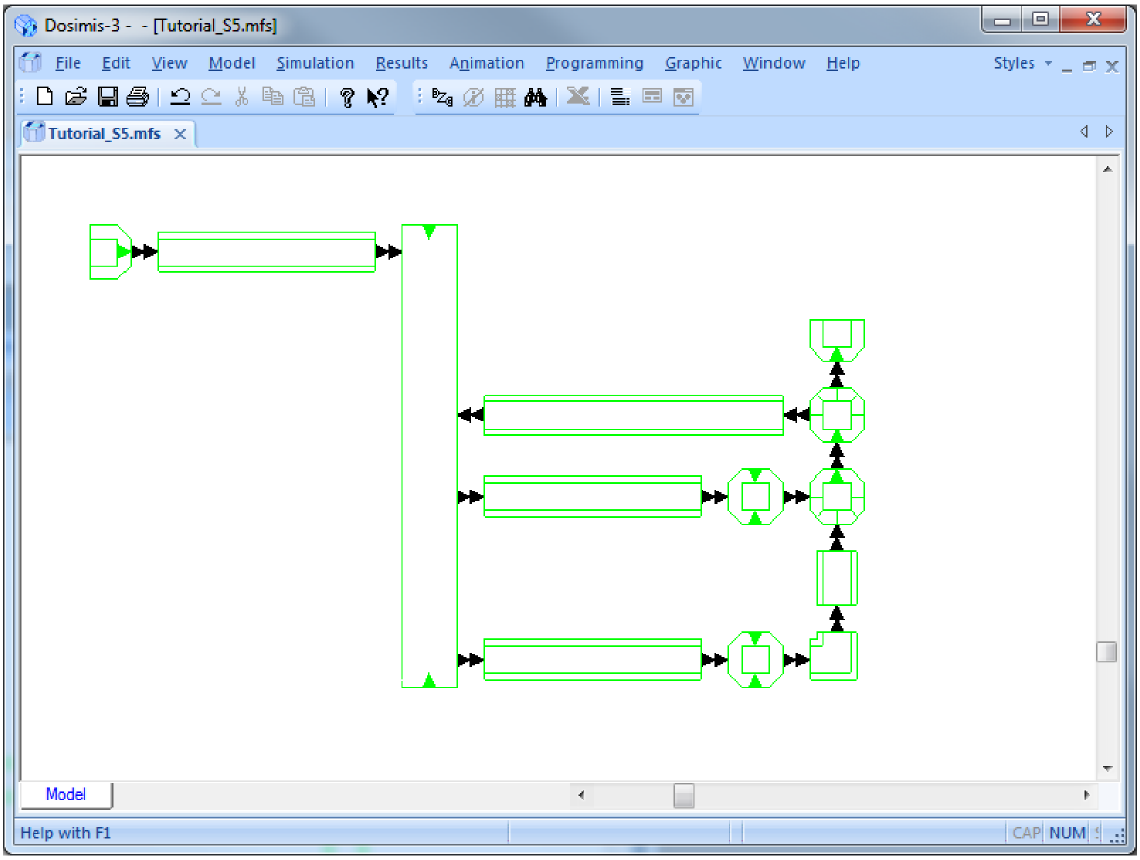


Figure 3.4a: Finished model layout

Linking mode has to be disabled now. Therefore please select **Model/Linking active** from the menu bar. As sign that the linking mode has been disabled, the node symbol below your mouse cursor will disappear.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

3.2 Input of Data with the Aid of Parameter Masks

3.2.1 Parameter Source

In the next steps, module data will be entered. Double-click the source to open the following window (parameter-input mask):

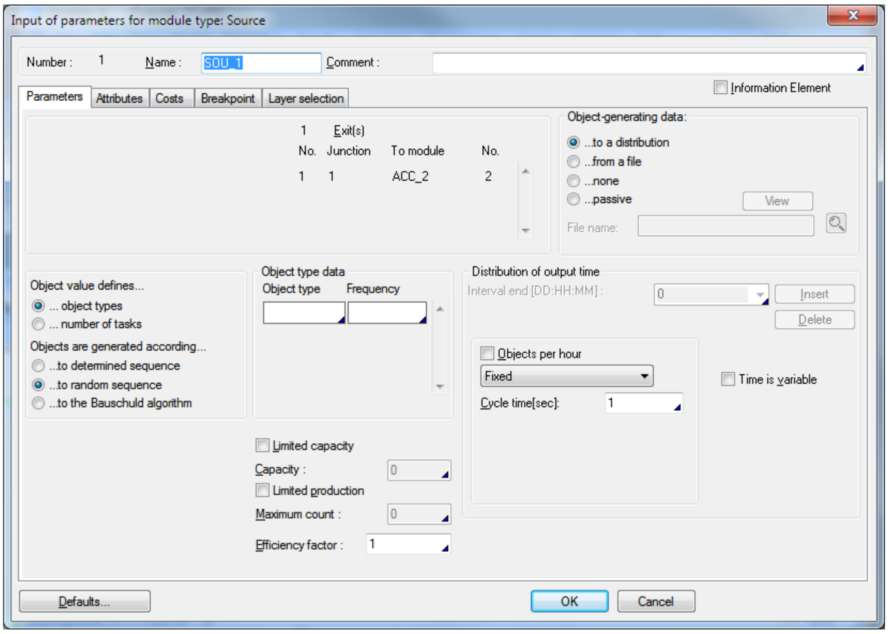


Figure 3.5: Parameter-input mask of the source

Every marked input box (circles: radio buttons and white boxes: input arrays) normally has to be edited. You can use the "Tab" button on your keyboard to jump forward to the next input box. Use "Shift" and "Tab" button to jump backwards. Or select the input box directly by clicking it with the left mouse button.

The Module Number is assigned automatically, Name and Comment can be skipped.

a) Object Generation Data

Objects shall be generated in random sequence- on average a defined distribution will result, however, only after a sufficiently large number of samples. So, please select the radio button named "…according to a distribution".

b) Object Type Data (object type and frequency)

The relative frequency of objects (here product groups) to appear, is entered according to the following table. Please use the "Tab" button on your keyboard to jump to the next input array and to add a new line of input arrays.

object type	frequency
1	50
2	50

This means, that both types will occur within a probability of 50 %.

c) Distribution of Output Time

By a click on the button at the right side of the combo box a drop-down list opens which contains all available types of distributions. Please select “normally distributed” from the combo box. Now enter 60 seconds as “mean” (expected value) and 5 seconds as deviation. All other settings remain given by default. In the end the parameter input mask should look as follows:

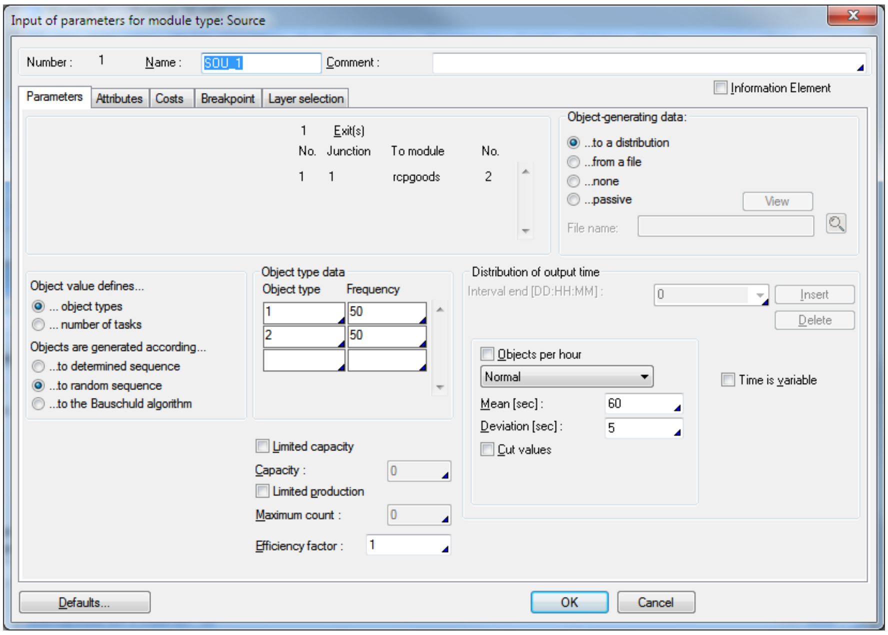


Figure 3.6: Completed parameter input mask of the source

To leave a parameter input mask and to confirm the entries made, please hit the “Enter” key on your keyboard or click on “OK” button of the mask.

3.2.2 Parameter Accumulation Conveyor

The parameters of the accumulation conveyor are entered in the same way. To open the parameter input mask, double-click on the module. Our model contains six accumulation conveyors.

Parameters are partly different. All accumulation conveyors of interest receive a special module name. These module names will help you to understand and to interpret the results.

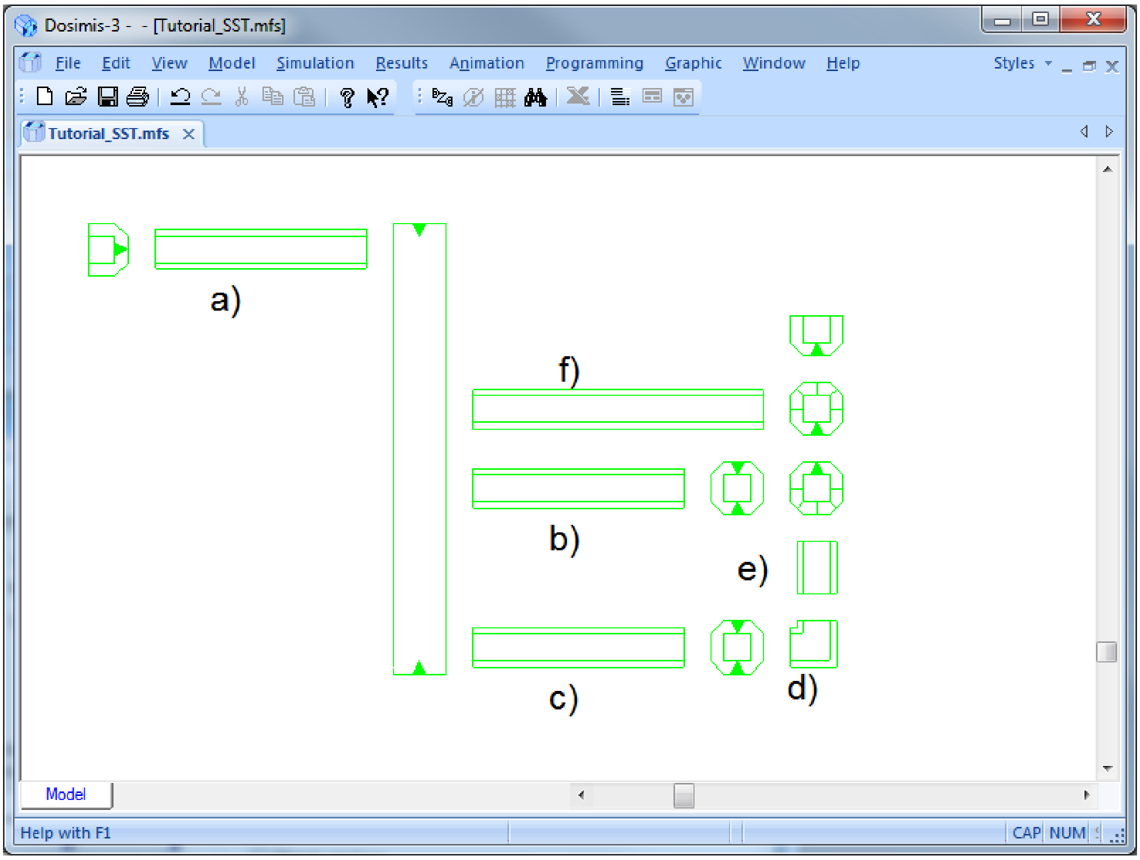


Figure 3.7: Assignment of the accumulation conveyors

To a): Buffer at receipt of goods

Only the first four lines of the parameter input mask are of interest for this model. These lines contain the conveying system data. The number of the module is generated and cannot be changed. Please enter the values of the following input areas as shown below:

Name:	*rcpgoods* (default: ACC_2)
length of segment (length of a component or pallet):	1 m
conveying speed:	0.2 m/sec
capacity (number of segments):	10 parts

The following figure results from these entries:

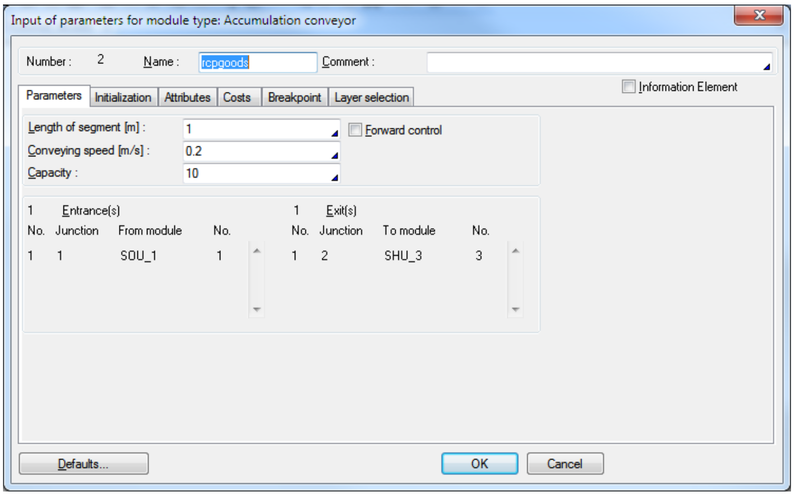


Figure 3.8: Parameter-input mask of the ACC after the source

To b) and c): Buffer before work station

Please use the same parameters as in a) except for capacity and module name. The capacity (number of segments) of the ACC is 2.
Module names: ACC_Above, ACC_Below

To d): This is an edge conveyor

Same data as in a) except capacity of 1 and the forward control has to be activated by clicking on its check box. A new pallet is only allowed to enter the conveyor after its preceding pallet has left the edge conveyor.

To e) and f): Connecting buffer and feed back conveyor

Same data as in a) except capacity of 4 in ACC e) and 3 in ACC f). Please remember to save your model occasionally.

3.2.3 Parameter Shuttle

Enter of shuttle data.
The following data sets, gathered in a box with light gray borders, have to be entered for the shuttle. From Top to bottom the shuttle parameter-input mask contains:

- Conveying data
- Entrance and exit assignment
- Dimensioning (on right side of entrance/exit assignment)
- Right-of-way strategy
- Distribution strategy

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Conveying data:

- loading path for one palette: 1.1 m (10 cm longer than palette length)
- loading speed for one palette: 0.2 m/sec
- unloading path per palette: 0.1 m
- unloading speed per palette: 0.2 m/sec

- calculation of travel time: slow/fast
- slowly driven path for the car: 0.5 m (acceleration/deceleration distance)
- speed fast: 1 m/sec (maximum speed of the car)
- speed slow: 0.1 m/sec (average positioning speed of the car).

The remaining conveying data will not be changed.

Dimensioning:

Please use the values of following table:

Entrance	pos. [m]	height	Exit	pos. [m]	height
1	0.0	0.0	1	20.0	0.0
2	15.0	0.0	2	25.0	0.0

This dimensioning data result from the creation of a coordinate system at the shuttle path. Its origin is close to the receipt of goods (Entrance 1), the end is close to the "ACC_Below" (Exit 2).

The height is used to reproduce a lifting movement and is not needed here.

All other settings remain as given by default. The completely filled up parameter-input mask for the shuttle should like shown below:

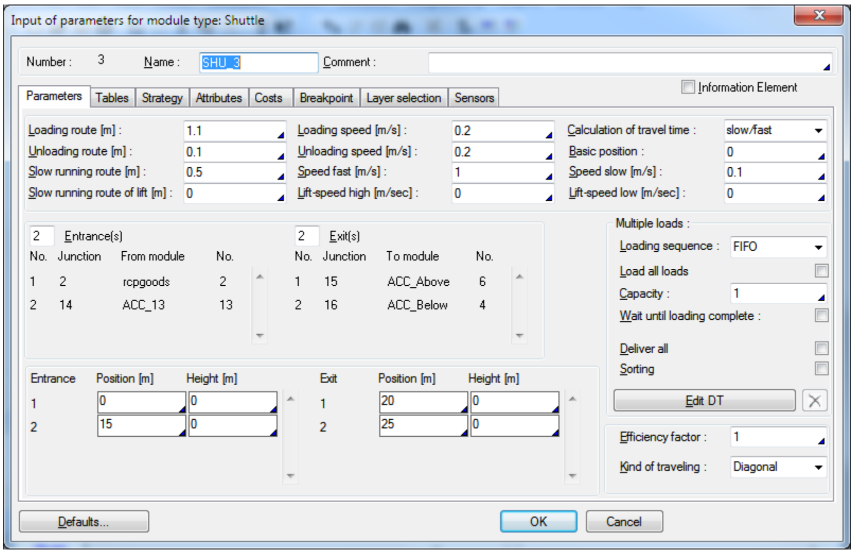


Figure 3.9: Parameter-input mask of the shuttle

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Entrance and Exit assignment:

Entrance(s): 2 (receipt of goods and feed back)
Exit(s): 2 (to both work stations)

Right-of-way strategy:

The right-of-way strategy makes the decision which palette will be carried as next one. Select **"priority of entrances"** from the combo box.

Priority of Entrances:

Entrance	**Priority**
1	1
2	2

Assigning of entrance numbers will be done later when connecting the modules. Following assignment will be done:

Entrance 1: receipt of goods buffer
Entrance 2: feed back conveyor

Priority 1 is highest, therefore priority 2 is of lower priority.

Distribution strategy:

The distribution strategy defines the exit, to which a pallet will be moved. Please select **"destination with"** from the combo box, enter object type 1 at first, then use the "Tabulator" button on your keyboard to jump into the input area of the second object type and enter 10, now click on the "next exit" button and act in the same way for exit 2 using the values of following table:

Destination with

exit	object type
1	1
	10
	(next exit)
2	2
	20

The object type is one type of product (group). Product type 10 is assigned to rework of product type 1, 20 is assigned to rework of product type 2.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

The completely filled-up strategy dialog for the shuttle should finally look like shown below:

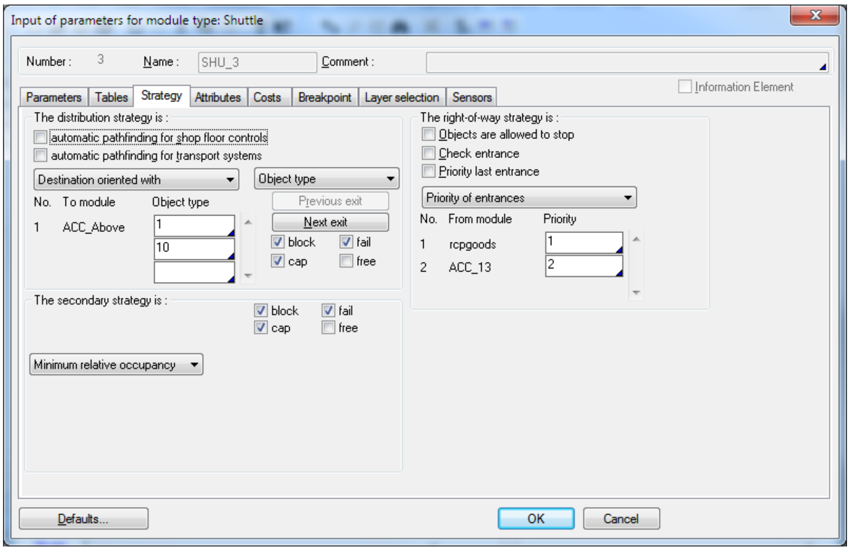


Figure 3.9a: Strategy input mask of the shuttle

3.2.4 Parameter Work Station

When entering the parameters of the work station (WST), you have to edit the following data sets:

- Conveying data
- Entrance and exit assignment (no data input!)
- Transport parameter
- Work procedure
    - Distribution of working time
    - Initial object
    - Set-up times

"Transport parameter" data sets are of no importance, because they are only required for transport systems. In this tutorial we use "Above" as the module name for the upper work station and "Below" for the lower one.

Conveying data:

The length of work station is equivalent to the entry length of one palette.

Length: 1 m
Conveying speed: 0.2 m/sec

Distribution of working time:

Select "normally distributed" from the combo box. This sets "normally distributed" as default for the following distribution settings. Now first enter object 1, then use the "Tabulator" button on your keyboard to jump into the input area for distribution. As you can see the preselected item (normally distributed) is highlighted. So please use the "Tabulator" button to jump into the next input area called mean and enter 80. Hit the "Tabulator" button again and

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

enter 5 as the deviation. Now press the “Tabulator” button to jump into strategy and leave the setting on “none” as it is. To open a new line, please hit the “Tabulator” button again and repeat the inputs for object type 10 in the same manner according to the following table. All time values are in seconds.
Important: To adopt the settings of a line, you have to enter the input area “strategy”!

normally distributed

Work Station	***objects***	***mean***	***deviation***
Above	1	80	5
	10	80	5
Below	2	80	5
	20	80	5

Initial Object:

You will find all objects defined previously in the initial object combo box. The initial object combo box contains the numbers of objects that enter the work station. As you remember two types of objects enter each work station (“OK objects” and “rework objects”). Now we must define for each kind of object the probability of leaving the work station as an “OK object” or as a “rework object”. Object numbers 1 and 2 are assigned to “OK objects”, object numbers 10 and 20 are assigned to “rework objects”. Please enter the number of the “new object” leaving the station with its “probability” for each object selected from the “initial object” combo box according to following four tables.

For work station **“Above”:**

initial object 1 (entering)		**initial object 10 (entering)**	
new object (leaving)	probability	new object (leaving)	probability
1	85	1	85
10	15	10	15

For work station **“Below”:**

initial object 2 (entering)		**initial object 20 (entering)**	
new object (leaving)	probability	new object (leaving)	probability
2	85	2	85
20	15	20	15

Set-up Times:

The set-up time is executed only if there is a change of object type. Please enter the values from following table in the same manner as described in “Distribution of working time” (see above) using the “**fixed**” distribution here:

Work Station	**from object**	**to object**	**cycle time**
Above	1	10	60
	10	1	60
Below	2	20	60
	20	2	60

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Same data are used for both work stations. It is the shuttle that controls which product is carried to which work station. By this time the work station has received the necessary information to proceed. Now the parameter input mask of one work station should look like shown in figure 3.10:

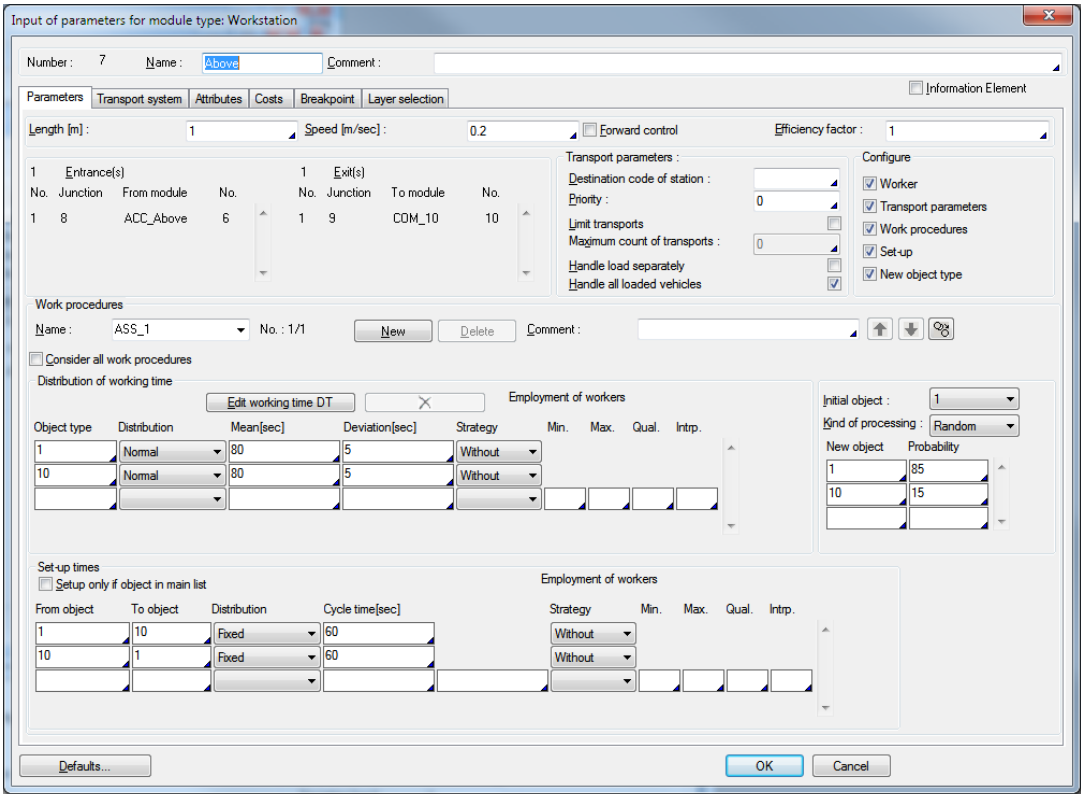


Figure 3.10: Parameter input mask of one work station

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

3.2.5 Parameter Combining Station

There is not much data left to be entered in the remaining modules. In summary, the following data sets are to be entered:

<u>Combining station</u>:

- *Conveying data*
  - conveying path: 1 m
  - speed: 0.2m/sec
- *Entrance- and. exit assignment*
  - Entrance(s): 2
- *Right-of-way strategy*
  - FIFO

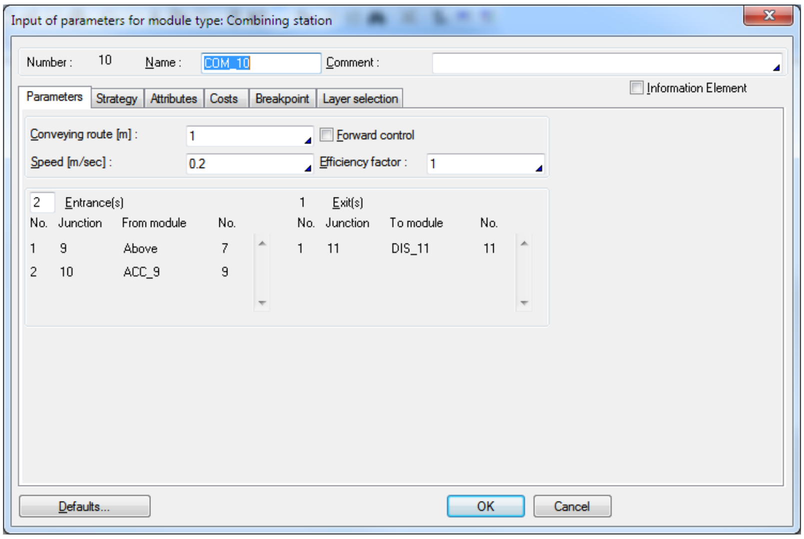


Figure 3.11: Parameter input mask of the combining station

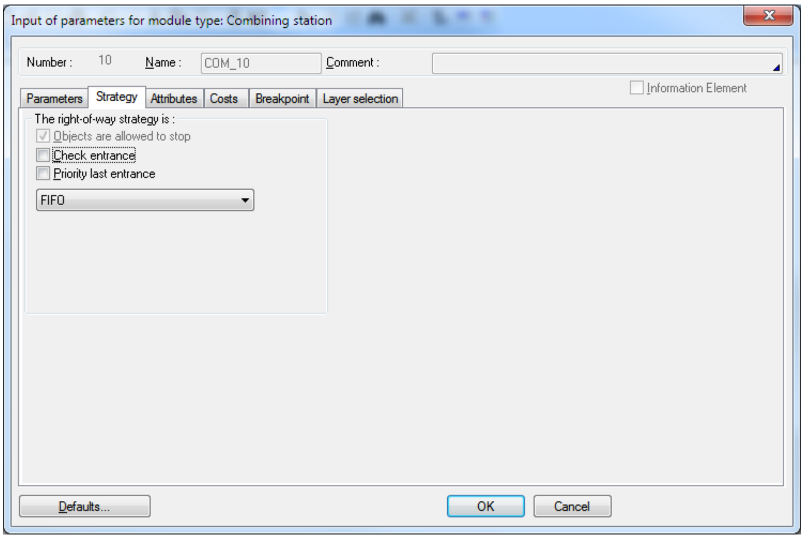


Figure 3.11a: Strategy input mask of the combining station

3.2.6 Parameter Distributor

Distributor:

- *Conveying data*

  conveying path: 1 m

  speed: 0.2m/sec

- *Entrance- and. exit assignment*

  Exit(s): 2

- *Right-of-way strategy*

  destination with (combo box)

Exit	**Object type**
1	1
	2
(next exit)	
2	10
	20

By using the distribution strategy “destination with (object type)” object types are assigned to one exit. The secondary strategy has to be edited if one object type can use more than one exit, because then the assignment is not unique.

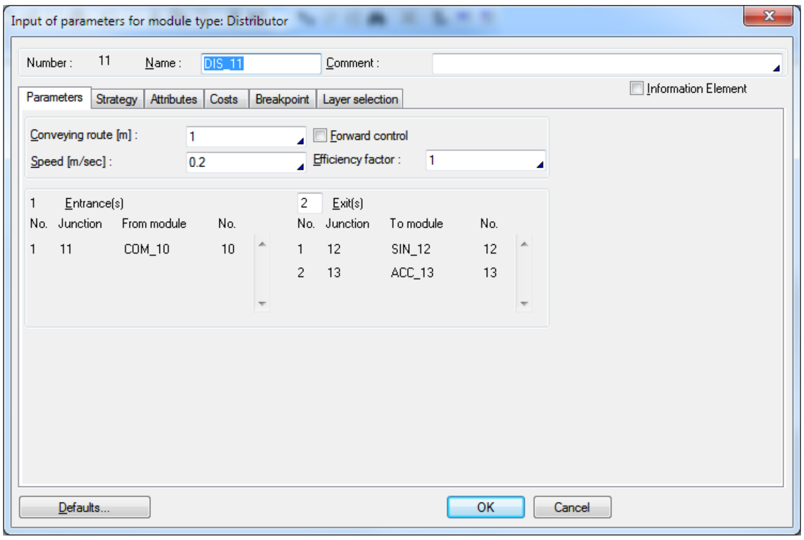


Figure 3.12: Parameter input mask of the distributor

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

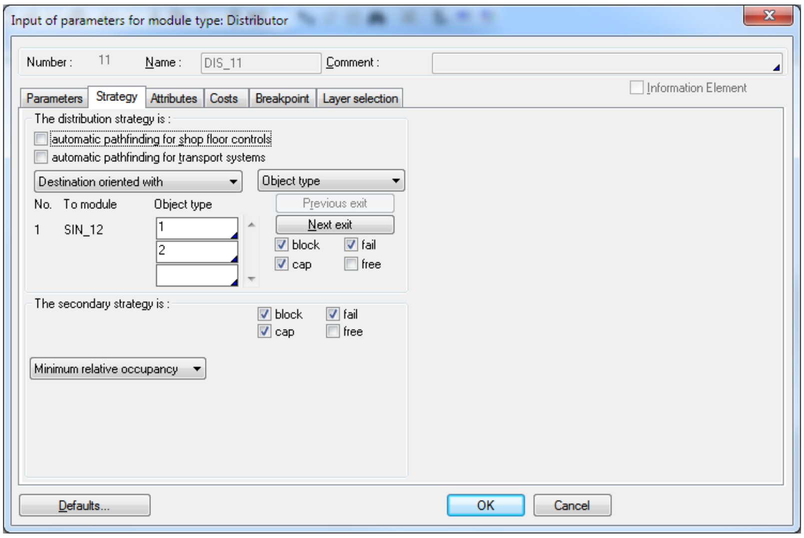


Figure 3.12a: Strategy input mask of the distributor

3.2.7 Parameter Sink

Sink: Please select “expo. distributed” from the combo box as distribution of leaving time and enter 55 sec. as mean.

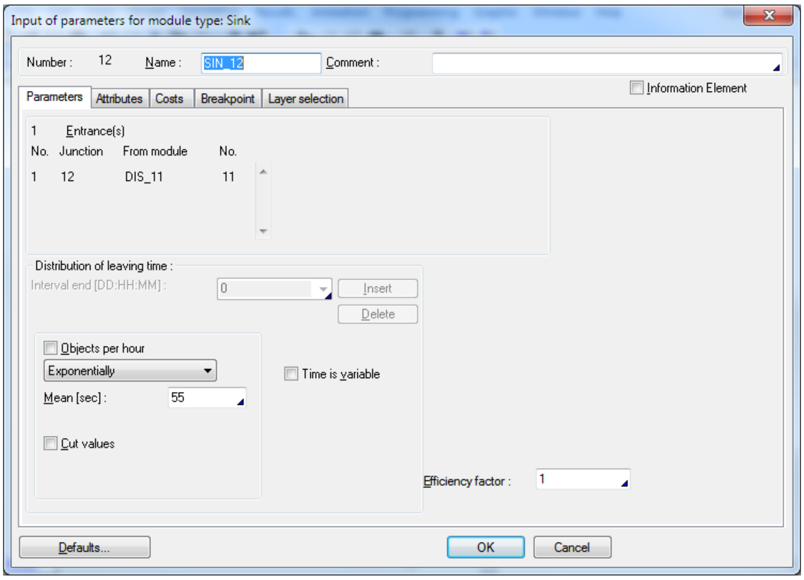


Figure 3.13: Parameter input mask of the sink

That completes the entire input of module parameters, so please save your model.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Now you have finished your model and the model window on your computer screen should look as follows:

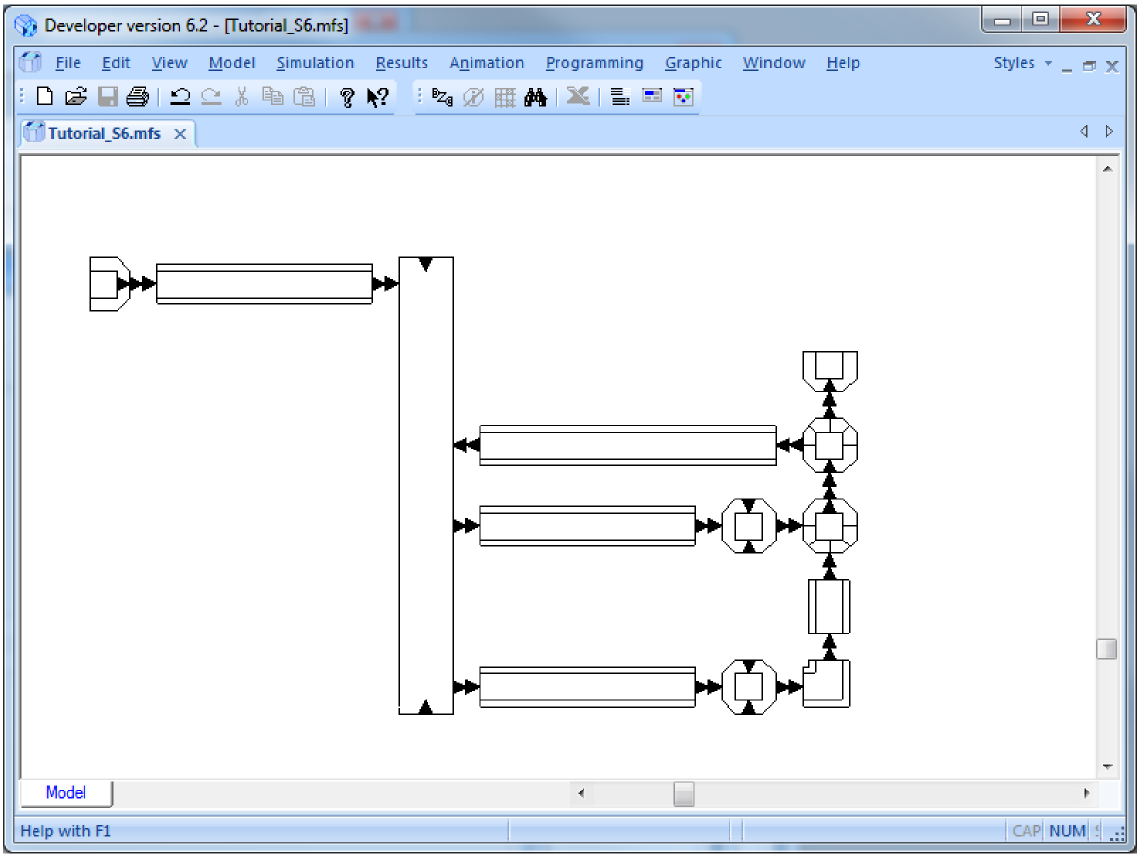


Figure 3.14: Finished model layout

3.3 Starting a Simulation Run

Before starting a simulation run you have to enter the simulation parameter. Please select **Simulation/Parameter** from the menu bar. The simulation parameter window appears. You can enter all time values in minutes. Please enter the following values:

simulation time	300	(results to 5 hours)
pre-run	0	(no pre-run for statistics)
statistic interval.	60	(every 60 minutes statistical data are collected)

All other settings remain as set-up by default. Before starting the first simulation run, please select **Simulation/Consistency check** from the menu bar. This activates some check routines that execute a restricted integrity check (parameter input data and links). This menu item is disabled if a successful consistency check has been done before.

To start the simulation, please select **Simulation/Start** from the menu bar. The DOSIMIS-3window disappears and a window appears containing a blue progress bar. This window will disappear as soon as the simulation run is finished and the DOSIMIS-3window will be opened again. The disappearing of the DOSIMIS-3window during the simulation can be averted by

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

deselecting the check box “hiding” in the simulation parameter mask. Now the collected results can be analyzed.

3.4 Results

In the next step we will look at the animation.

Here the time flow of object movement is visible. For this purpose please select **Animation/Parameter** from the menu bar. The animation parameter window appears.

Please select the radio button “*time factor*”. The display speed is set by the *time factor*. Please set the value of this time factor to 30 (default is 60). Therefore 30 minutes of simulation time will be displayed during 1 minute real time. (Please note that accurate work of time factor can be affected by performance and utilization of your computer.) Then select **Animation/Start** from the menu bar - animation is executed. Boxes in different colors and numbers inside are displayed inside the modules. The displayed colors have the following meaning:

green: status „waiting“ or „moving“
red: status „blocked“
blue: status „working“

Result of the first run is a deadlock - no more movements - after a short time. (Figure 3.15). This problem can be removed by changing parameters (see chapter 4). For this purpose the animation has to be stopped at first. Please select **Animation/Stop** from the menu bar.

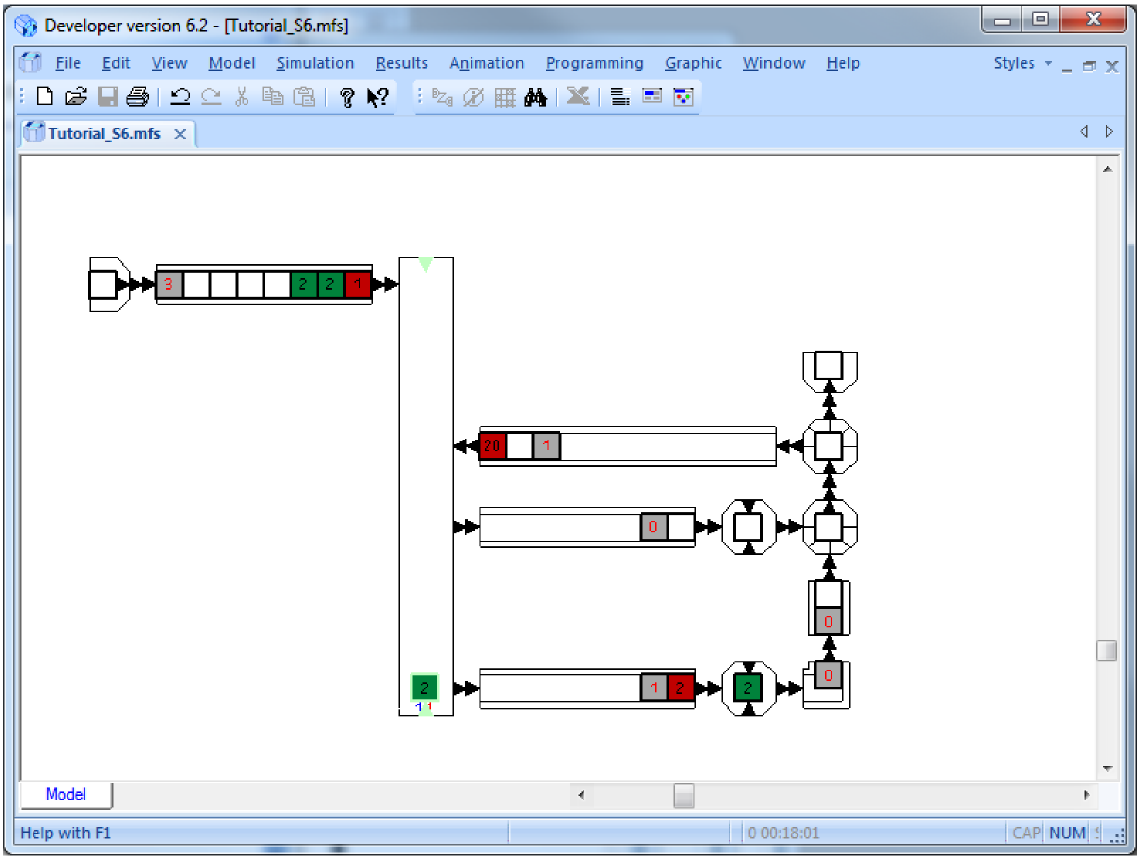


Figure 3.15: Process animation in the production system

Next we will attend to statistics.

A deadlock occurred during the first simulation run. Now the occupation of the source and of the buffer at receipt of goods is of interest. At first the modules of note have to be selected. Please click the source with the left mouse button, then press the “Ctrl” button on your keyboard and click the accumulation conveyor next to the source with the left mouse button. After this, please select **Results/Buffer analysis/Occupation diagram** from the menu bar.

The following picture will be displayed as a new window inside the DOSIMIS-3 main window.

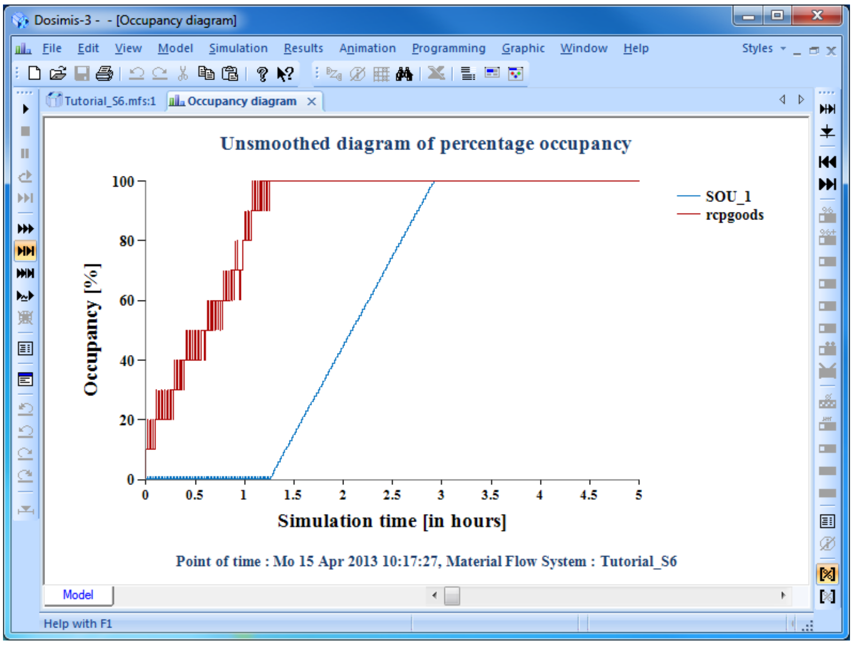


Figure 3.16: Occupation diagram

The capacity (in percent) of the buffer at the source and the source are shown over time. There are 10 % steps within the occupation of the incoming goods buffer for one palette inside the buffer.

Depending on random order a few deviations may occur in the pictures. To display the utilization of the work stations you must perform similar steps. Click the first work station then click the second work station while pressing the “Ctrl” button to select both work stations and select **Results/Module histogram** from the menu bar.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

The following diagram appears as a new window inside your DOSIMIS-3 main window:

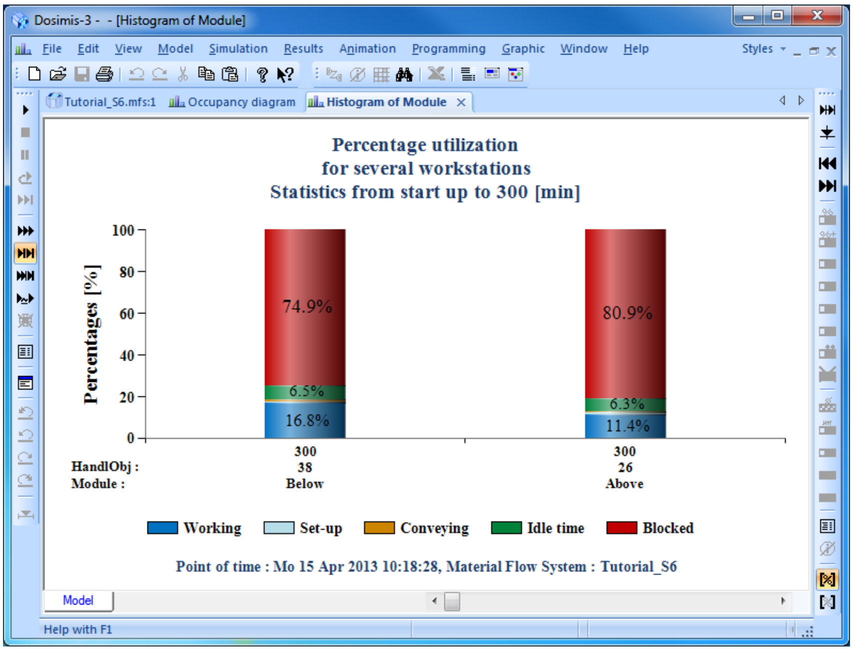


Figure 3.17: Module histogram

Utilization of work stations is displayed in the "*module histogram*". To perform our task we will have to focus on following items: "working", "set-up", "idle time" and "conveying".

3.5 Problems

When using a simulation system, some "surprising moments" may occur. These unexpected exceptional cases can be divided in two categories:

- program bugs
- handling errors

Program bugs:

- Program crash of simulation software
  Precaution: Save your model as often as possible!
  If a model was destroyed by a program crash you can retrieve the backup of the last saved model. The backup files are named modelname.dbk and modlename.mbk where "modelname" is the name you assigned to your model (default "modelname" is DOSIMIS-3-1). To back up the last saved model, please rename the files **modelname.dbk** to **modelname.dar** and **modelname.mbk** to **modelname.mfs**.

Handling errors:

There are some operating sequences that sometimes cause confustion. The following cases have occurred in practice:

- Wrong selection for statistic data
  Module histograms can only be displayed for work stations and shuttles. If any other module was selected to display module histogram an error message is displayed in a new window. To quit this message click on the "x" symbol in the upper right corner of this message window (but do not click on the "x" symbol of the DOSIMIS-3 window!!!).

- Sometimes a user forgets to disable "linking mode" after connecting modules. The active "linking mode" is visible by a displayed node below the cursor and links are displayed in green color. A lot of usual operations are not possible in "linking mode".

4 Experiments using the Practice Example

4.1 Initial Situation

The small production system was planed and shall be checked again by aid of simulation.

Open questions concern the dimensioning of buffer sizes and the strategies to control the equipment.

The layout, in particular the arrangement of incoming goods as well as the technical data of production (working times and quota of rework) are not changeable within the scope of planning. Starting point for further analyses is the completely entered model as described in chapter 3.

Following steps of optimization result from our first simulation run. (Important: result diagrams must not match this presentation exactly - depending on the sequence of inputs slight deviations may occur.)

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

4.2 Steps of Optimization

4.2.1 Step 1 - Deadlock

Start:

Animation parameter (starting at 0, time factor 30). A deadlock occurs after a short time - no more movements are visible.

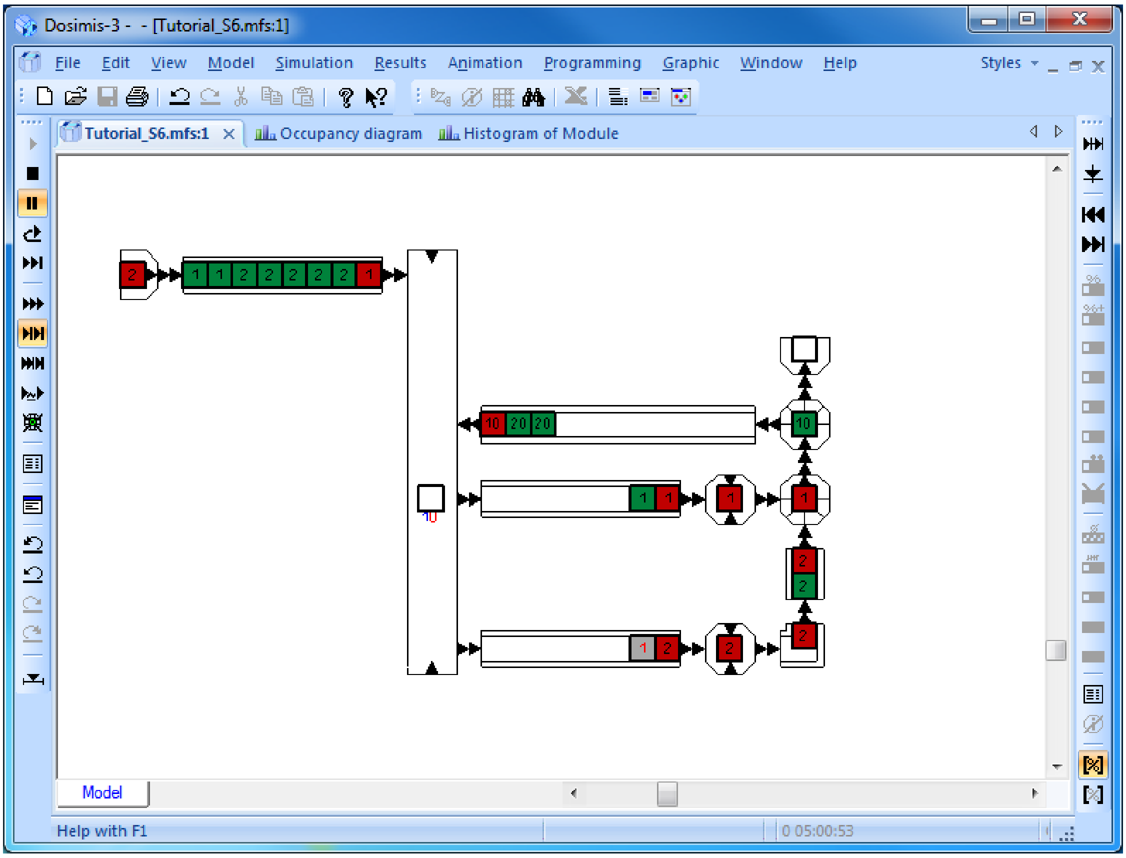


Figure 4.1: Deadlock

Cause:

The distributor contains an object for the destination feed back conveyor (rework), but the feedback conveyor is full. This object blocks the material flow and causes reverse blockages.

In the case of more precise consideration we can identify two material flow circuits. A small one, that is composed of the shuttle, the ACC before upper work station, the workstation itself, the combining station, the distributor and the feedback conveyor.

The big circle consists of the elements of the material flow containing the workstation below. The shuttle does not pick up any object in case of a jam. The control unit of the shuttle and the storage/retrieval machine does not allow picking up objects, if the object cannot be delivered. Even if this control statement did not exist and the shuttle would pick up and carry the next object to its destination, the object could not be unloaded.

A first proposal to solve the problem could be to increase the buffer size of the feedback conveyor. This leads, however, to deadlocks again and again - the appearance of the deadlock is only retarded since critical situations occur less frequently - they are not avoided in this way.

Conclusion:

The actual cause of the deadlock is the wrong priority in shuttle control. The feedback conveyor has to dispose of the elements with higher priority.

4.2.2 Step 2 - Presorting

Measure:

Please open the parameter input mask of the shuttle and change the entrance priority.

Right-of-way strategy

Entrance	Priority
1	2
2	1

Priority “1” is the highest; therefore priority “2” is of lower priority.

Please start a simulation again. Select **Simulation/Start** from the menu bar.

Start:

a) Occupancy diagram of the source and the ACC after the source: The diagram shows *that buffers become full very soon. The source has a capacity of 100 objects (therefore* one object is equivalent to one percent). After 5 h about 80 - 90 objects have retailed in incoming goods (inside the source).

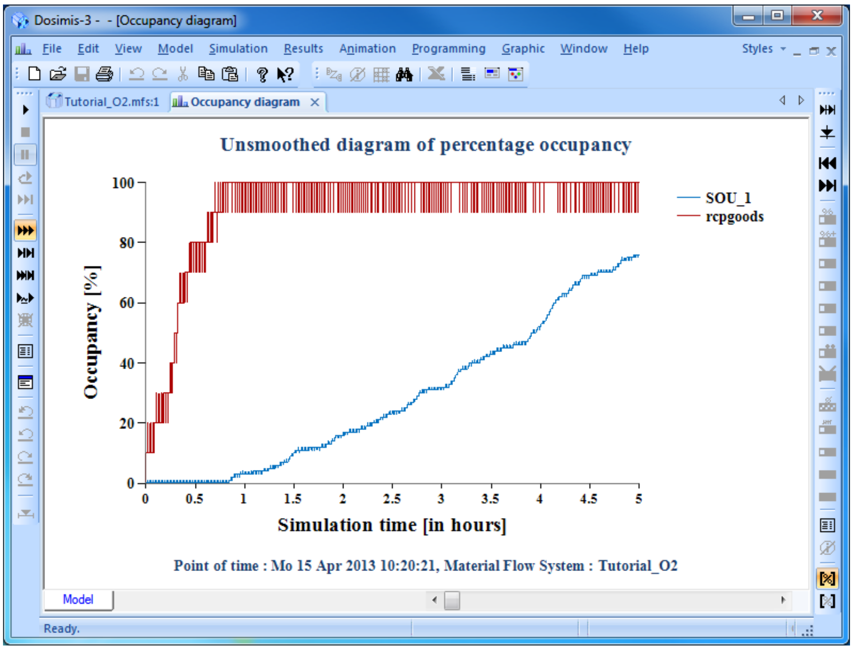


Figure 4.2: Occupancy diagram of the source and its following ACC

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

b) Module histogram of both workstations: As you can see both workstations are idle (green) for about 20 % of time.

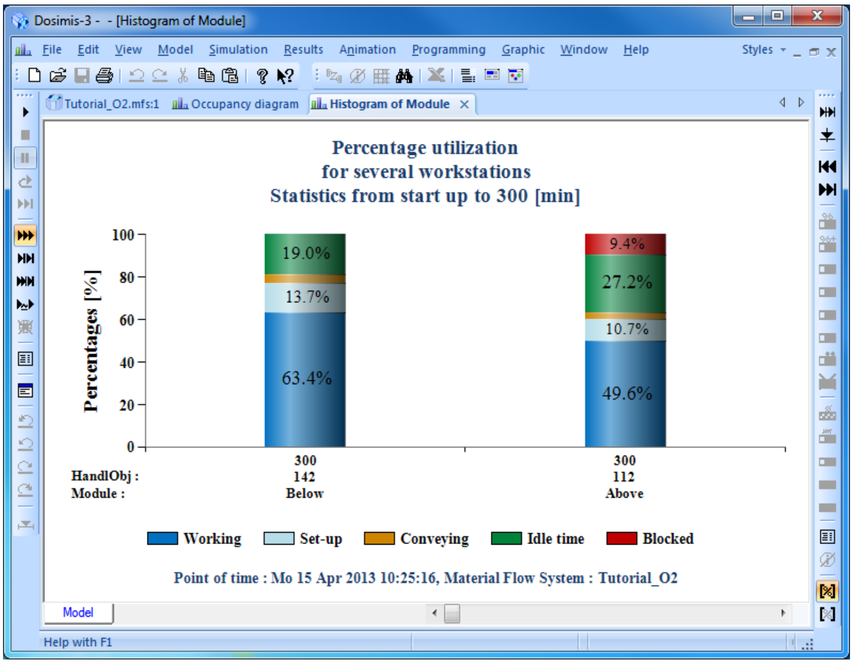


Figure 4.3: Module histogram of both work stations

c) Module histogram of the shuttle: There is idle time too - even though the value is a little bit smaller.

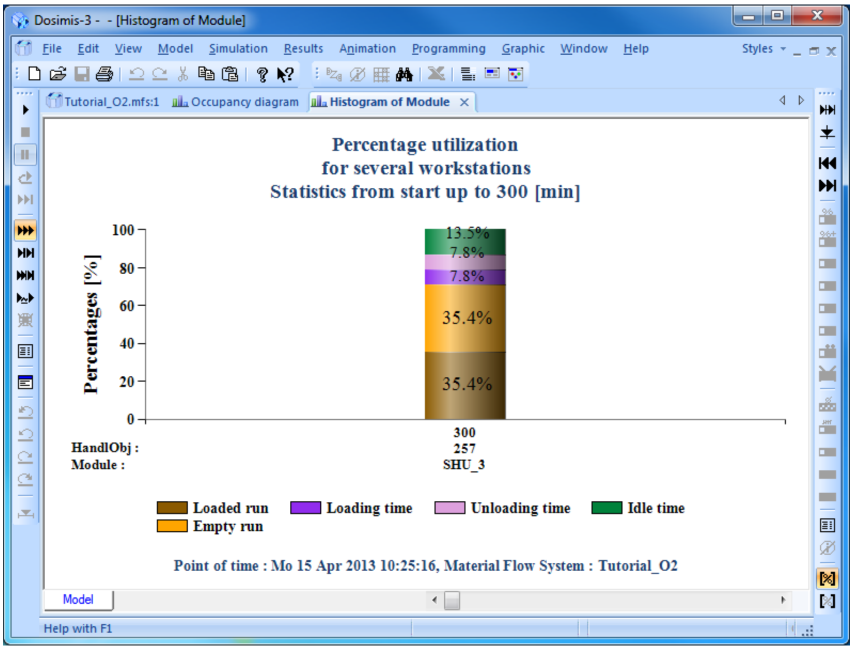


Figure 4.4: Module histogram of the shuttle

Conclusion:

Work stations and shuttle are waiting (idle) for some time but there is a jam of parts at the incoming goods (source).

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Cause:

Products of type “1” and “2” appear in irregular sequence. They are balanced in the long run, but in smaller time intervals, the product mix can unfavourably swing to one or the other side.

Size of the buffer between shuttle and workstation is too small for these variations. One of the buffers before the workstations is filled up- if the same type of product now waits at the end of the buffer after the source, the buffer before the other workstation will become empty and at least that workstation will become idle

Different measures could basically be considered:

a) Sorted delivery of goods at the source.
Components of type 1 and 2 will be delivered in batch size 1 or 2 (that means alternating).
Disadvantage:
The preliminary system has to sort the components - problems are shifted outside. In addition the random onset of rework will confuse every normal sorting.

b) Flexible distribution of products 1 and 2 onto both work stations - according to volume of work.
Disadvantage:
Big set-up efforts to change from product 1 to 2 and vice versa as well as expensive investments for highly flexible machines

c) Presorting of products from the source onto two side-by-side sorting conveyors at the receipt of goods.
Disadvantage:
Though there are tailbacks which affect alternating on both work stations, one sorting conveyor always will fill up and finally will block the supply of the neighboring conveyor.

d) Increase size of the buffers between shuttle and work stations.

4.2.3 Step 3 - Decoupling (Increase of Buffer Size)

Measure:

Measure d) will be realized in this step. Please increase the buffer size of the accumulation conveyors between shuttle and work stations. A typical value for these capacities may be 4 or 5. This is the number of segments on one accumulation conveyor.

Then please save your model and start another simulation run.

Start:

Occupancy diagram of the source and its succeeding conveyor: As you can see the reverse blockage inside the source decreased only a little - the measure was ineffective.

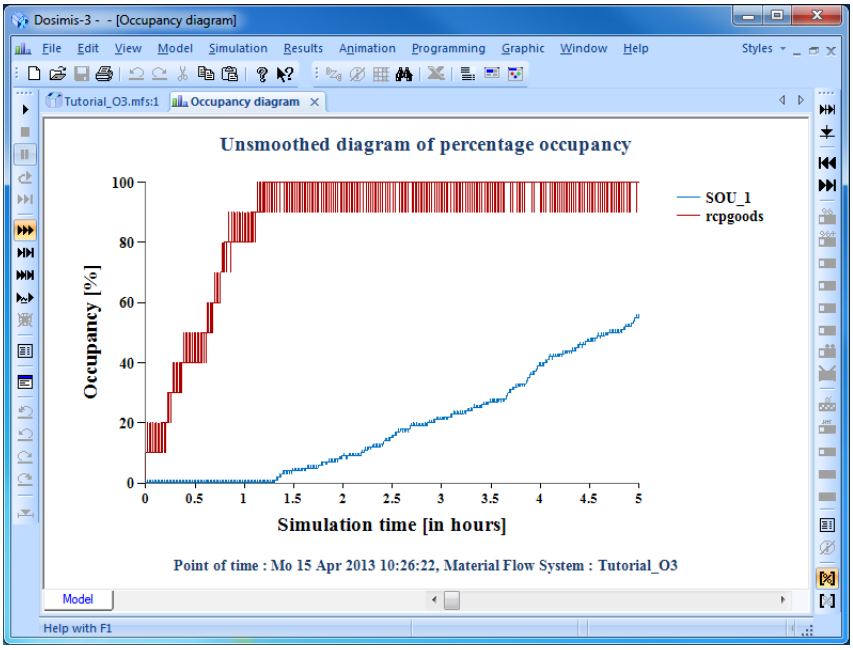


Figure 4.5: Occupancy diagram of the source and its succeeding conveyor

Cause:

No direct cause can be recognized, the causes of step 2 are still basically valid.

Conclusion:

Simulation technology affords the opportunity to analyze circumstances, initially independent of investment possibilities.

The actual measure in step 2 was to decouple the critical modules work station and shuttle. We wanted to analyze if problems could be solved by decoupling.

Measure:

Please increase the capacity of the accumulation conveyors in front of the work stations again and use the unrealistic value of 10 this time.

Then start another simulation run.

Start:

Occupancy diagram of the source and its succeeding conveyor: The reverse blockage decreased only a little - especially if you consider that buffer capacity of the whole system was increased significantly.

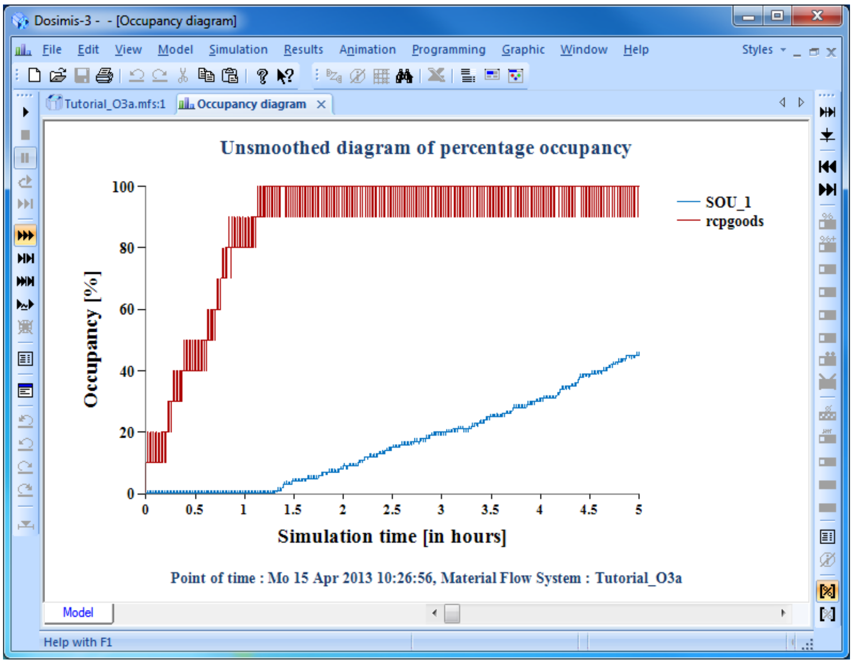


Figure 4.6: Occupancy diagram of the source and its succeeding conveyor

Occupancy diagram of ACCs before work stations: The buffer below is never filled up and the buffer above is well used.

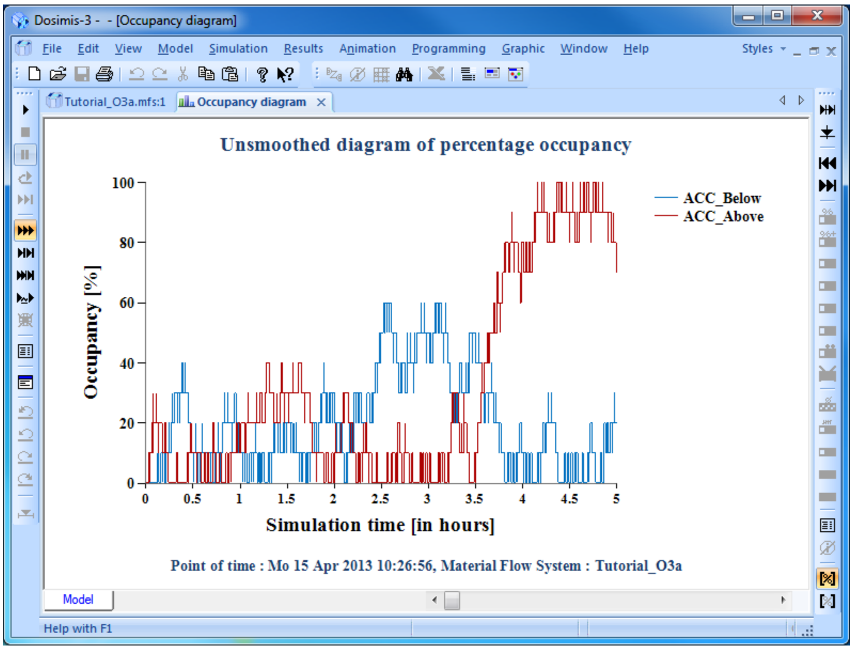


Figure 4.7: Occupancy diagram of ACCs before work stations

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Conclusion:

The shuttle must be the bottleneck, because the buffer before the shuttle is filled up all the time and the buffers behind the shuttle are not filled up all the time. A look at the module histogram of the shuttle shows that the shuttle has nearly no more idle time.

4.2.4 Step 4 - Increase Shuttle Speed

Measure:

The shuttle has to become faster. A technically and economically reasonable value amounts to 2 m/s maximum speed. Please enter 2 m/s as the new value of “speed fast” in the parameter mask of the shuttle.

Afterwards, please start another simulation run.

Start:

Occupancy diagram of the source and its succeeding conveyor. Reverse blockage is now clearly smaller - however still present.

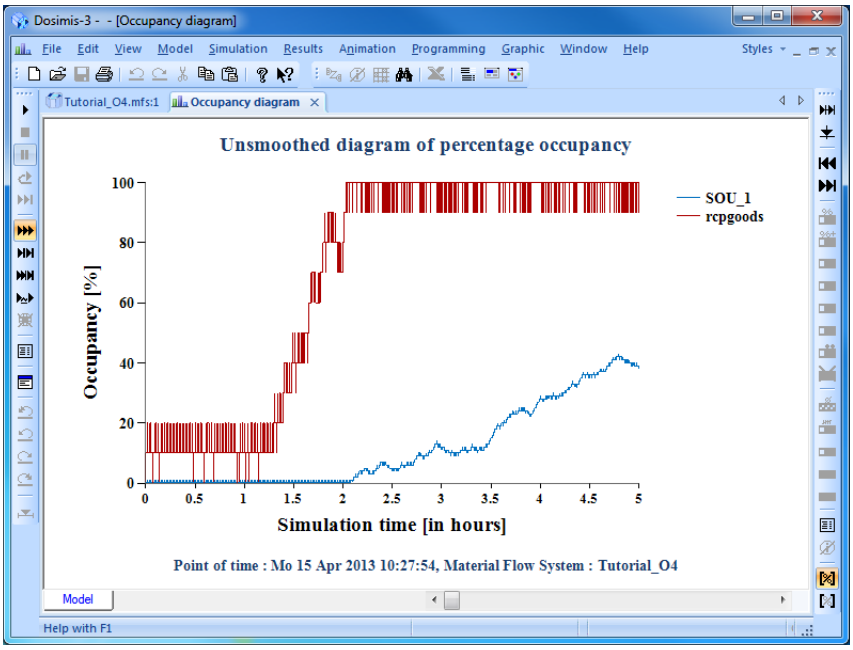


Figure 4.8: Occupancy diagram of the source and its succeeding conveyor

Module histogram of both work stations: The upper work station proves a relatively high blockade portion (about 20 %, displayed in red color).

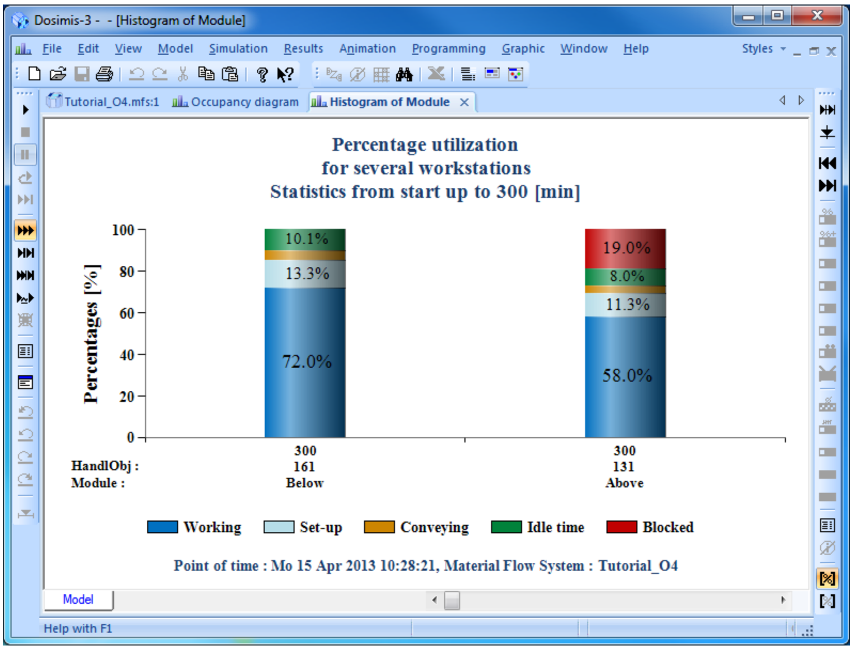


Figure 4.9: Module histogram of both work stations

Cause:

Due to varying process times of the sink, sometimes longer queues form in front of the sink. These queues repeatedly block the accumulation conveyor before workstation "Above" - workstation "Below" is not affected in the same way because there is a buffer of 5 places behind that work station.

4.2.5 Step 5 – Preferred Disposal

Measure:

Please change the "right-of-way" strategy of the combining station: The entrance connected directly to work station "Above" shall be favored - please assign priority "1" to this entrance and priority "2" to the second entrance (connected to the accumulation conveyor).

Then start a new simulation run.

Result:

A look at the occupancy diagram of the source and its succeeding accumulation conveyor shows that the last measure was not efficient.

Cause:

The jam at the combining station results from the dynamic behavior of the sink. Changing the priority of right-of-way changes nearly nothing ; the jam at the combining station remains. Workstation "Below" is not affected in the same way because its distance to the sink is larger compared to work station "Above". Due to a jam at workstation "Above", the accumulation

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

conveyor before this workstation will be filled up - this ACC is no longer able to receive objects of type “1”. A filled-up buffer is no buffer anymore - it lost its operativeness.

4.2.6 Step 6 - Buffer before Sink

Measure:

Please insert an accumulation conveyor between distributor and sink. To decouple the sink buffer capacity should be set to 10 (number of segments). The best way to do this is to copy an existing module (e.g. ACC before work station “Above”). Therefore click the module “ACC_Above” and select **Edit/Copy** and then **Edit/Paste** from the menu bar. A new module appears above “ACC_Above”. Right click this module and select **Element/Replace element** from the context menu. Now first click the distributor then the sink and press the right mouse button to complete this action. If the new module is not at the right place, then click this module and keep the left mouse button pressed while moving it to its destination. To fix the module release the mouse button. As the next step, switch to linking mode and connect the module to distributor and sink. Finally deselect the linking mode and save your model.

Now your model should look like shown below.

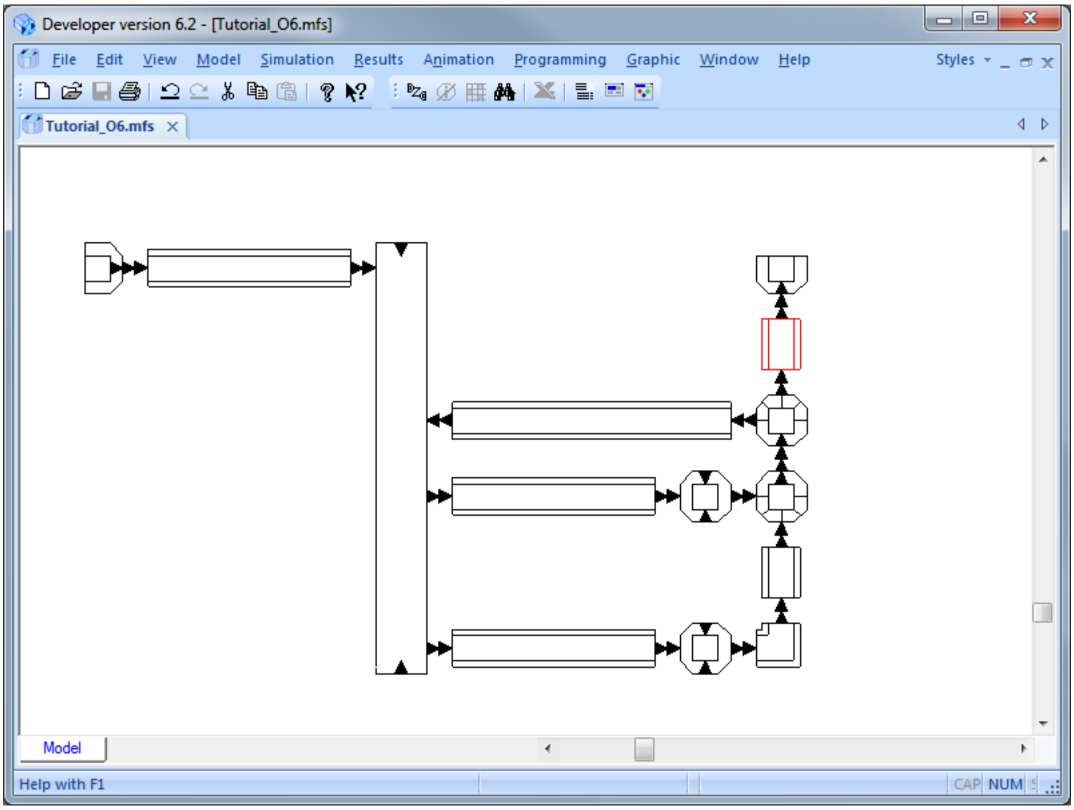


Figure 4.10: Layout with buffer before sink

Please start a new simulation run again.

Start:

Please look at the occupancy diagram of the source and its succeeding accumulation conveyor (see Figure 4.11):

The situation has partly improved - however, there is a reverse blockage on the accumulation conveyor. The stability of this system appears not to be safe, it could only be proved by a longer simulation time. Please enter 10 h as new simulation time in the simulation parameter mask and start a new simulation run.

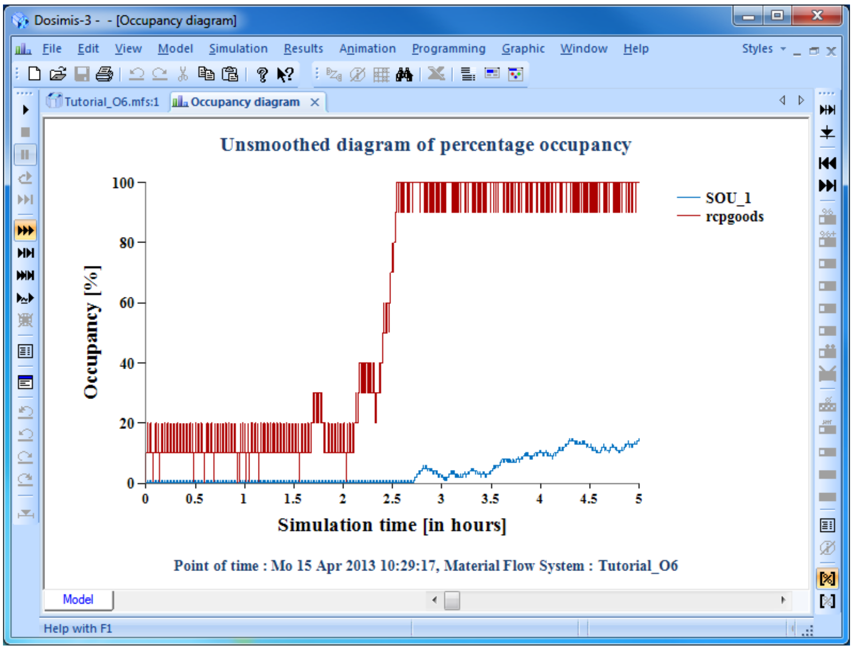


Figure 4.11: Occupancy diagram of the source and its succeeding conveyor (5h)

Regarding the occupancy diagrams of the source and its succeeding conveyor an unpleasant surprise occurs - the system is not steady and gets filled up (Figure 4.12).

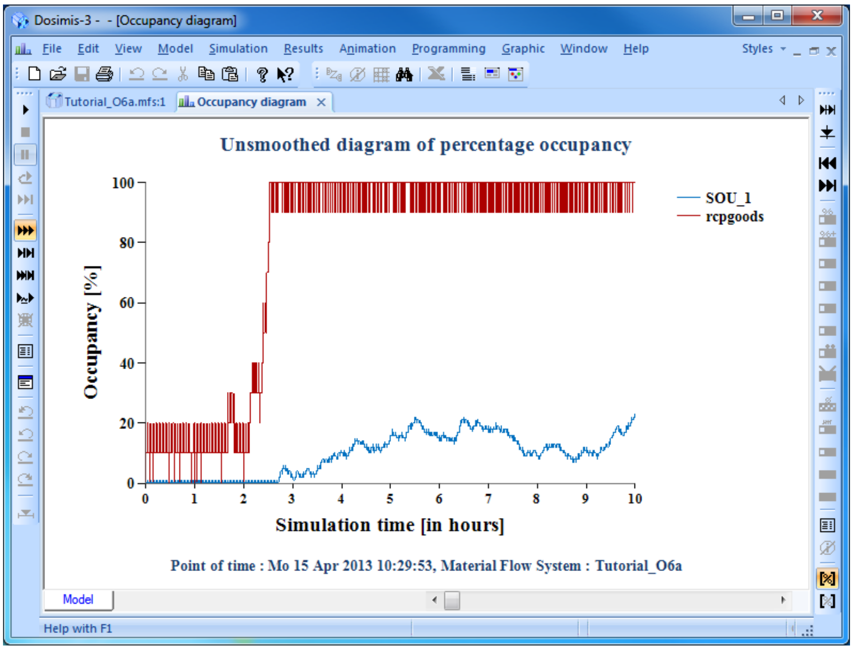


Figure 4.12: Occupancy diagram of the source and its succeeding conveyor (10 h)

Module histogram of work stations: As you can see both work stations still have free reserves (green, idle time). These reserves result from alternate filling up and emptying of buffers. An empty buffer causes a lack of parts at a workstation. These workstations are operated at the limit of their capacity.

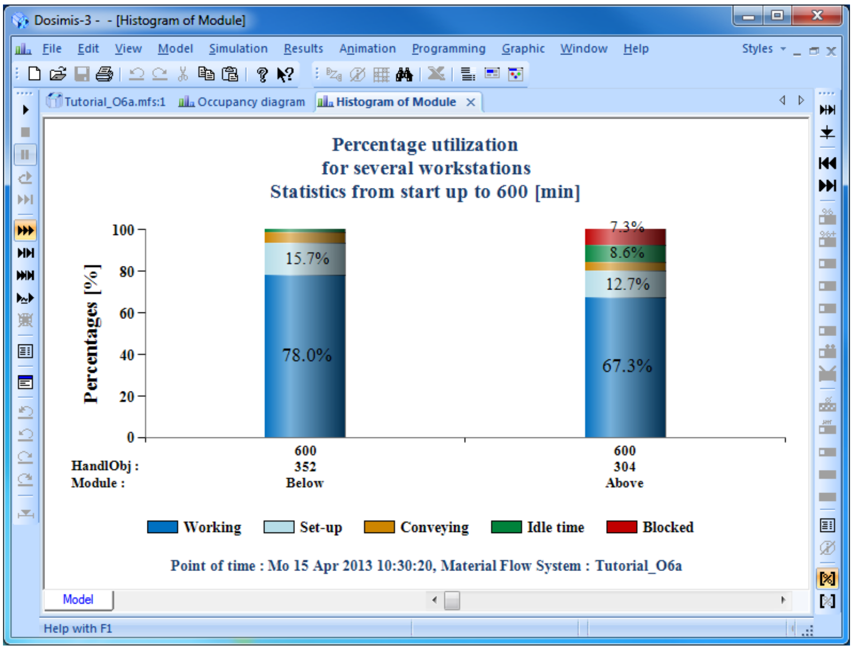


Figure 4.13: Module histogram of both work stations

Cause:

Because work stations reached the limit of their capability, reverse blockages are inevitable. This is also clearly visible in the diagrams of buffer occupation before work stations - they are filled up interchangeably again and again.

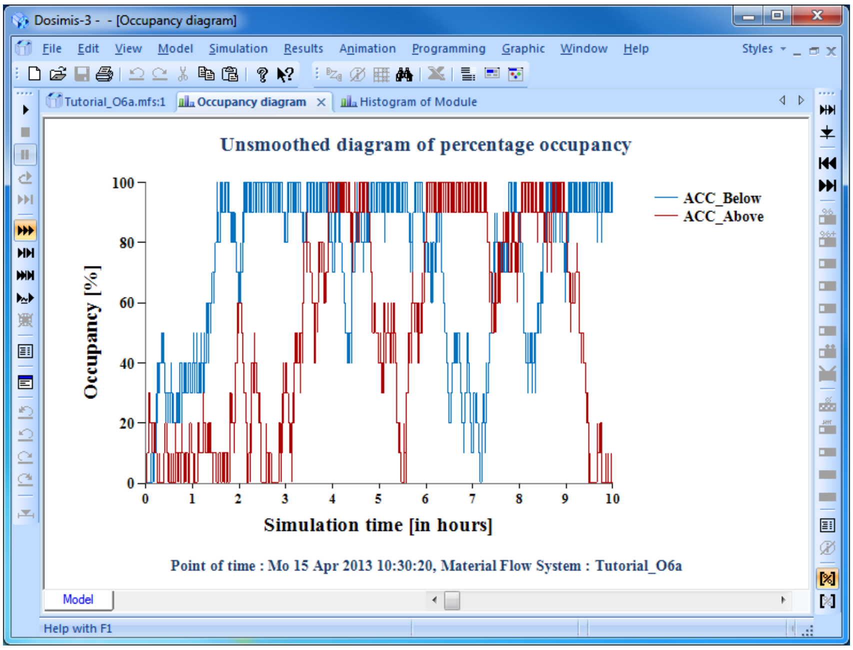


Figure 4.14: Occupancy diagram of buffer before work stations

Conclusion:

Since the system is exhausted and because work stations form the bottleneck, the only possibility is to use reserves.

4.2.7 Step 7 - Optimization of Set-up Time

Measure:

By assigning a high priority to the feedback conveyor as right-of-way strategy of the shuttle (to prevent the deadlock in step 1), a strategy of maximum set-up time indirectly results. It makes sense to reduce set-up time. One possibility to do this is to introduce a “lot size” at the feed back conveyor. In DOSIMIS-3 you can do this by inserting a “bulk conveyor (BUL)”.

The existing feedback conveyor with a capacity of 3 will be replaced by a bulk conveyor with a capacity of 8 and a preliminary accumulation conveyor with a capacity of 4.

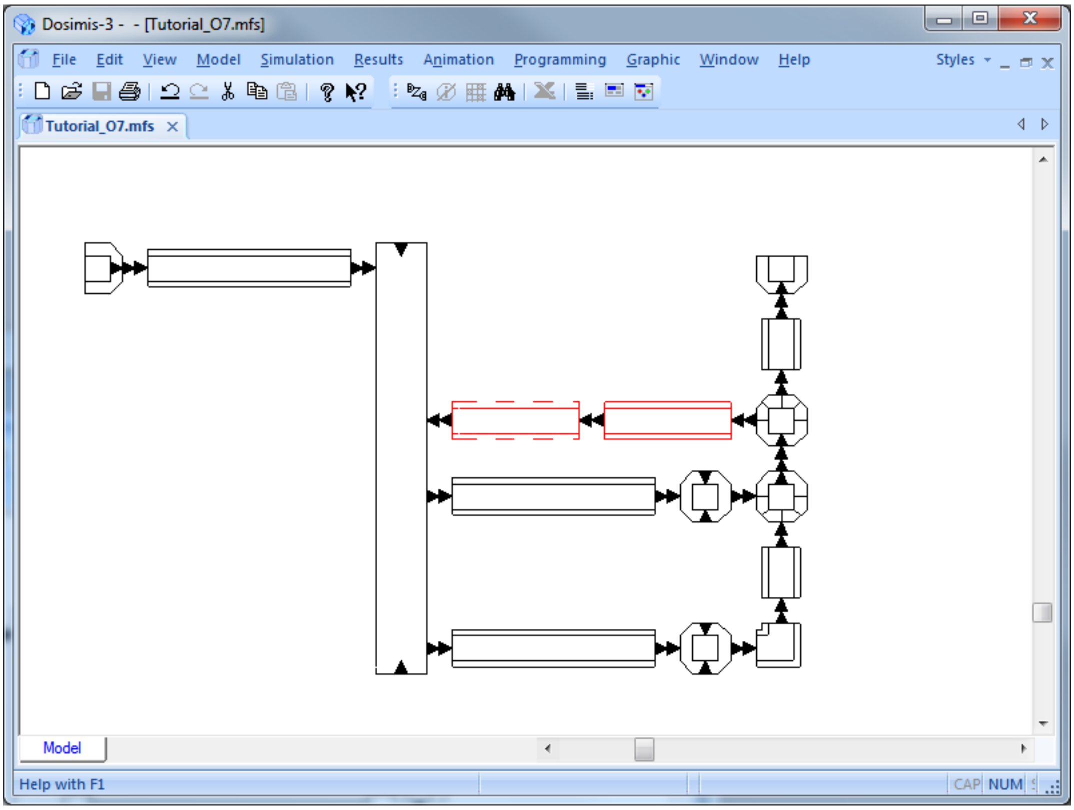


Figure 4.15: Layout with bulk conveyor and preliminary ACC

The bulk conveyor has following parameters::
length: 8 m
conveying speed: 0.2 m/sec
number of places: 8
Length indicates the total length, conveying speed defines unloading time.

A small buffer (with a capacity of 4) still has to be inserted between distributor and bulk conveyor. During unloading the bulk conveyor does not accept any object hat enters - so a deadlock situation might occur, which becomes more improbable because of the small ACC.

After this, please save your model and start a new simulation run.

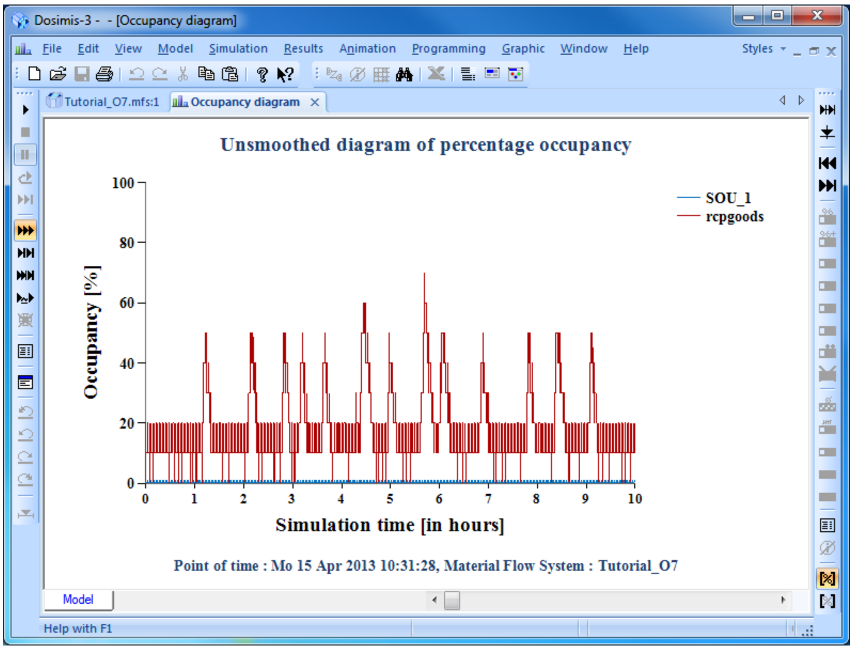


Figure 4.16: Occupancy diagram of the source and its succeeding conveyor

There is no more reverse blockage inside of the source - the system copes with the requested work load. Admittedly buffer capacity of the whole system is oversized. However the buffer before the sink is filled up often.

Cause:

The sink is still problematic. Due to its extreme distribution of departure time (exponential distribution) the sink repeatedly causes high loads inside the system. That is already visible in the Occupancy diagram of the buffer before the sink

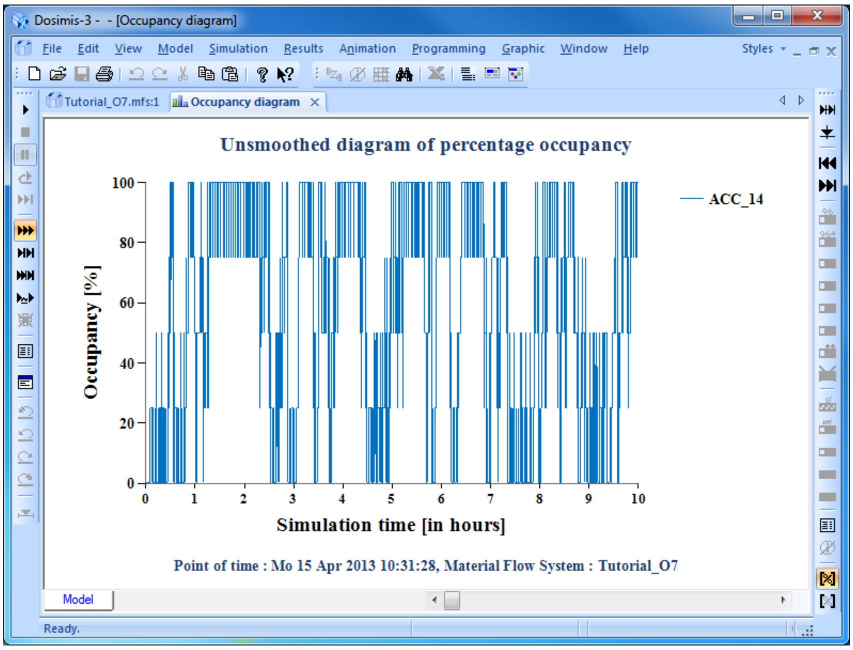


Figure 4.17: Occupancy diagram of the buffer before sink

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

4.2.8 Step 8 - Mitigation of the Sink

Cause:

By organizational measures in the plant (e.g. avoidance of cigarette breaks, stand-by workers in case of failures or overload, overcoming problem cases, etc.) it should be possible to attain an even workload of the sink.

Therefore we will analyze the behavior of the sink if “departure time” is normally distributed. Mean of 55 seconds is unchanged. The deviation is be 5 seconds.

Please start another further simulation run.

Start:

Occupancy diagram of the source and its succeeding conveyor: The source is able to dispense all palettes, sometimes little reverse blockages form on the accumulation conveyor due to deflation of the bulk conveyor.

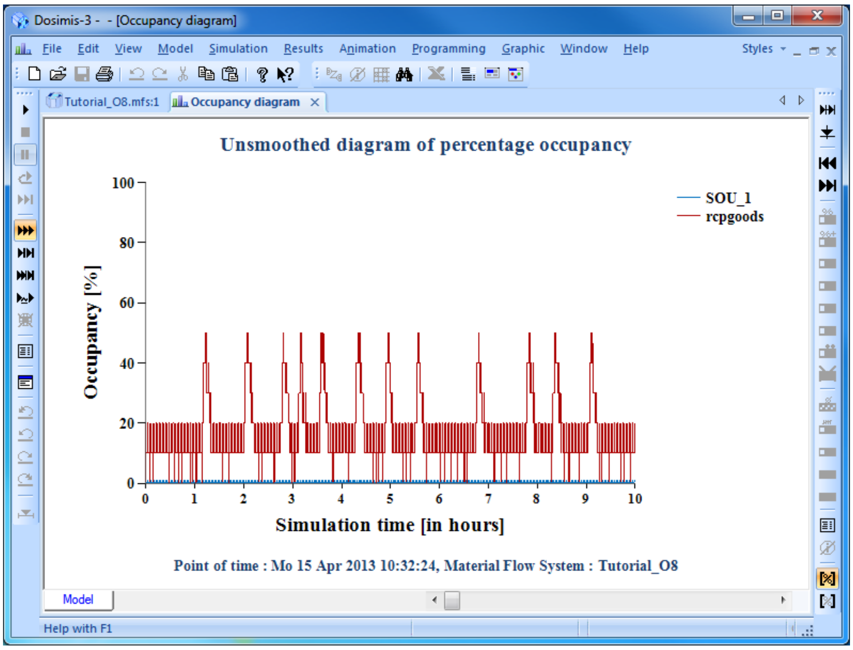


Figure 4.18: Occupancy diagram of the source and its succeeding conveyor

Module histogram of both work stations: as you can see, set-up times have decreased substantially and there are even “idle times” (about 15%) at the work stations again.

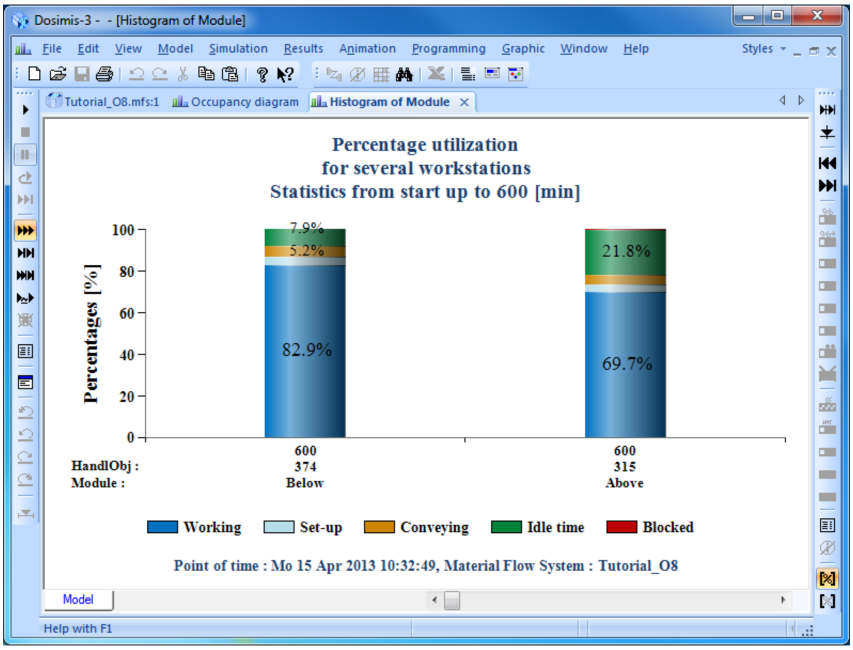


Figure 4.19: Module histogram of both work stations

Occupancy diagram of the buffer before sink: this buffer is barely filled to 50% anymore. More than three pallets are relatively rarely contained inside that buffer.

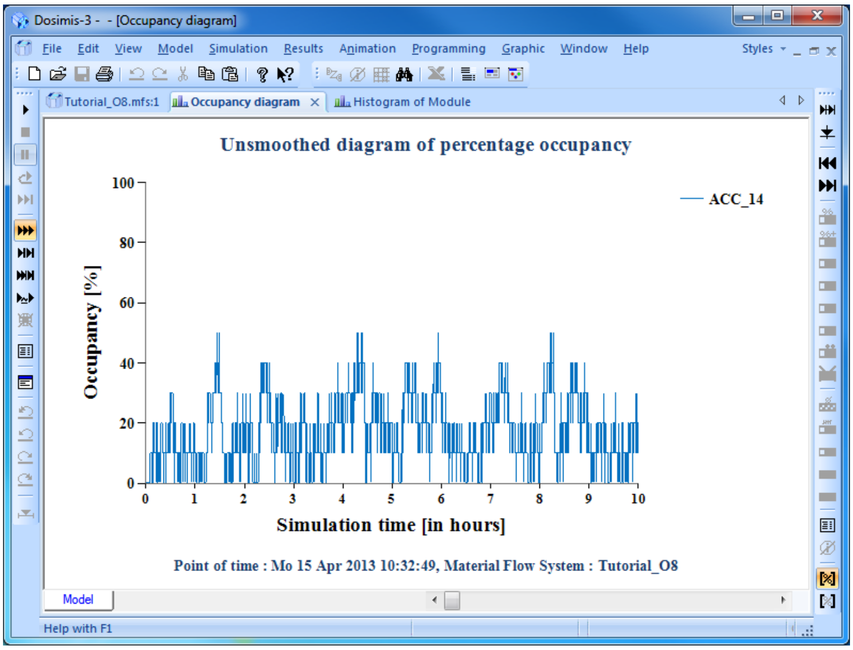


Figure 4.20: Occupancy diagram of the buffer before sink

Cause:

Due to changing the sinks dynamics (normally distributed) the buffer is hardly needed anymore.

4.2.9 Step 9 - Decrease of Buffer Size before the Sink

Measure:

The capacity of this buffer can be reduced to 2. Even if little reverse blockages appear at workstation "Above", this should have little effect on the system - workstations have reserves.

Please start another simulation run.

Start:

Occupancy diagrams of the source and its succeeding conveyor as well as module histograms of both work stations show that reducing of buffer size before the sink has no noteworthy effect on the system as expected.

Please select **Results/Result parameter** from the menu bar, enter the values as shown in Figure 4.21 and click the "Accept" button. Then select **Results/Turnaround-time statistics** from the menu bar. Two bars are visible, each representing one product. The minimal, average and maximal turnaround time is displayed for product 1 and 2 -from source to sink.

As you can see, the maximum time for products to remain in the system is about 2 h - the average time of about 15 - 20 minutes appears to be amazingly high. The minimal turnaround time is about 5 minutes and roughly corresponds to the value estimated by seminar participants.

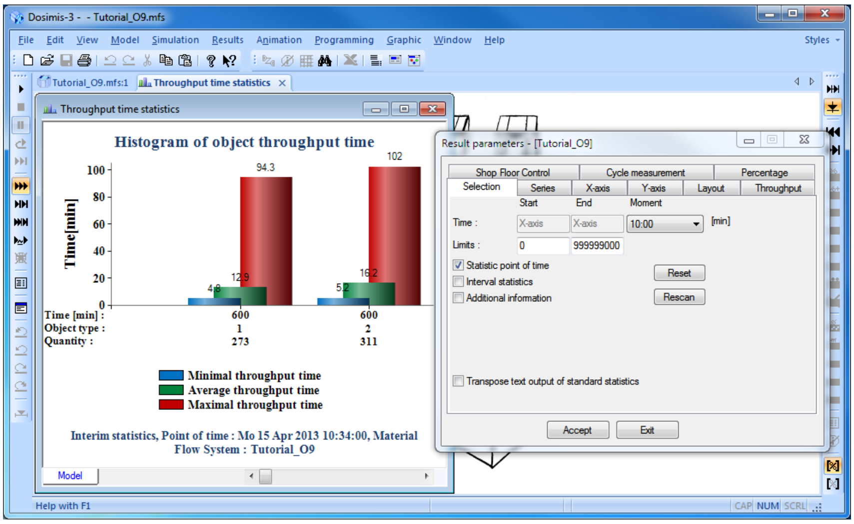


Figure 4.21: Diagram of turnaround time

4.2.10 Step 10 - Decrease of Buffer Size before Work Stations

Further Optimizations:

The reasons for high buffer occupations were explained already in Step 9. However, if this changing of buffer size has no effects on the throughput - what about further reductions? There are essentially several possibilities:

a) Further decreasing the size of buffer before the sink. The work station could stand quite smaller blockades - it still has reserves. However the appearing blockades actually result in breakeven performance that will fix the planed interval of the source at 1 minute.

b) Decreasing of bulk conveyor capacity. This is equivalent to the decrease of lot size, which means that quota of set-up time at the work stations will increase again. With that the breakeven performance of the system will be fixed as well.

c) Decreasing the size of buffers before the work stations. As you can see at the Occupancy diagrams buffers are filled up occasionally - but there still are significant reserves in the incoming goods buffer.

d) Minimizing the size of the buffer succeeding the source. The corresponding occupancy diagram shows that 5 places could be saved at once.

The resulting measure depends on the goals of the enterprise. On principle all measures affect in the same way - they reduce the range and flexibility of deviations of source frequency. Measures a), c) and d) affect the capital investments; measure b) furthermore affects the turnaround-time.

Measure:

Decreasing the size of buffer before the work stations from 10 to 8 places per conveyor - this measure reduces, first of all, the space requirements in the production area.

4.2.11 Step 11 - Factory Tuning

The examination of the statistics resulting from the measures in step 10 shows that the system generates the required performance.

Further Optimizations:

Sometimes planers have to answer the question: What has to be done to increase system performance - if necessary by changing organizational conditions. For example the question could be asked whether the production performance could be increased by 20 %, if rework is outsourced. This question shall be answered by a simulation run.

Measure:

Please increase the frequency of the source (decrease output time) and the sink (decrease departure time) by 20 %, that means:
Source, output time: 48 sec
Sink, leaving time: 44 sec

The distribution strategy of the distributor has to be changed - all objects must leave to sink.
Exit 1: Objects 1, 2, 10, 20
Exit 2: First delete the second entry then enter “99” in the first line (the first line has to contain a number greater than “0”, so we enter “99” as dummy, therefore all objects will leave at exit 1).

Then start a simulation run.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Conclusion

As the Occupancy diagrams of the source and its succeeding conveyor show, the problem has been conquered.

A look at the “Turnaround-time statistics” displays a surprise: The average value of turnaround times is about 8 minutes now and its maximum is about 20 minutes (admittedly without regarding on rework!).

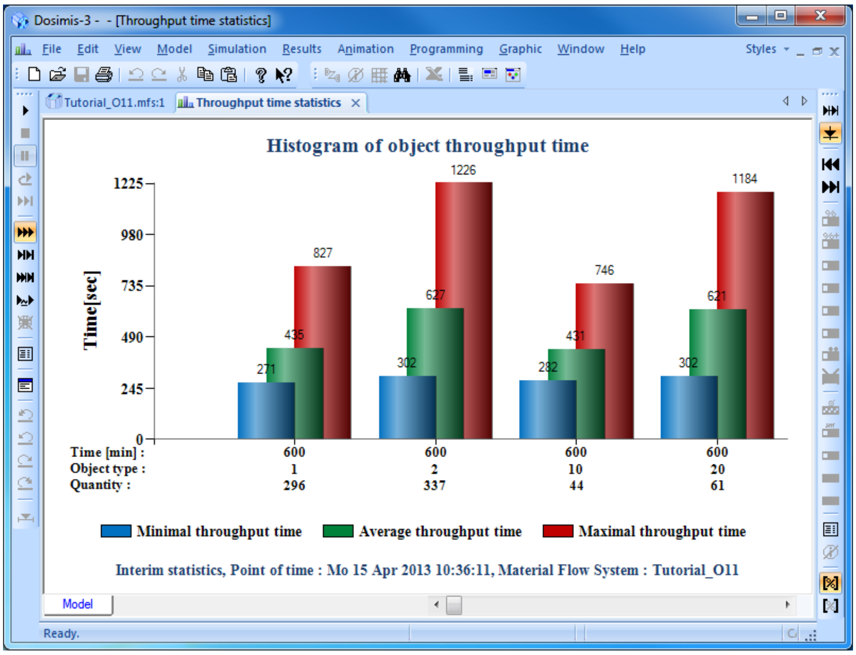


Figure 4.22: Diagram of turnaround times

The “small” rule of lot size multiplies turnaround time by about 3 (if rework is not regarded) - small measure, large effect.

Many production systems are much bigger than the one of this example. Often 500 or up to 3000 modules are used to reproduce a plant - using a lot of control rules (priorities, sortings, synchronizations) whose effects can barely be understood.

4.3 Results of this Simulation Study

In chapter 2.2.1 questions were asked that should be answered by simulation. Following answers result:

- Throughput of 60 parts per hour can be achieved, presumed that the measures taken can actually be accomplished in reality. The originally analyzed system did not achieve the work load approximately.
- The original system has a lot of weak points: shuttle (control strategy and performance), buffer sizes, quota of set-up times at work stations, and large deviation of sink performance.
- In the final model (step 10) workstations have a utilization of up to 90 %.
- The shuttle has a reserve of about 20 % resulting from the realized modifications.
- Behavior of the sink has substantial effects on the performance of the hole system - organizational measures are indispensable.

How the system behaves if failures occur has to be analyzed in further studies. Due to the bare design of work stations it can be assumed that the system reacts very sensitively to failures.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

5 Graphical Comments

When using DOSIMIS-3 to create a simulation model no time-consuming layout true to scale will be generated, since these functionalities are reproduced by an appropriate parameterization.

The avoidance of an accurate layout illustration allows an extremely fast modeling as well as the screen-optimal display of the system to be simulated. Assistance tools, such as zoom, copying of modules or module groups and the input of partial models taken from libraries, are available.

Layout can be complemented individually by texts resp. comments and by the aid of integrated paint functions, in order to arrange the model more descriptively.

5.1 Insertion of Graphical Elements

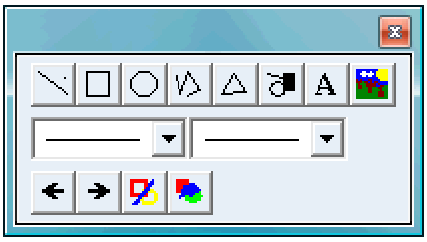


Figure 5.1: Graphic-palette

Please select **View/Tools/Graphic-palette** from the menu bar to activate the graphic-palette toolbar. You can create graphical elements in your model by using the buttons of the Graphic-palette. To insert a graphical element in your model, first click on the button representing the desired element on the “Graphic-palette”, then click at the point where you want to place the first edge of the element and click a second time on the point of the second edge.

5.2 Change the Size of a Graphical Element

To change the size of a graphical element, please select the element by mouse click and use the pulling points on its frame.

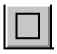
The grid is an invisible network of lines, which helps you to align the graphical elements. As a default the graphical element is drawn on the nearest intersection of the grid when placing. The default distance between two grid lines is 12. If necessary, you can change both the vertical and the horizontal distance between grid lines.

Please select **Edit/Snap parameters** from the menu bar to display or to edit grid parameters.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

5.3 Add a Rectangle

To draw a rectangle, please click the rectangle button of the symbol bar called Graphic palette

Symbol 

and place the element in your model. To change background or line color, please double-click the element to open the element dialog box.

By double-clicking on a rectangle following dialog-box appears.

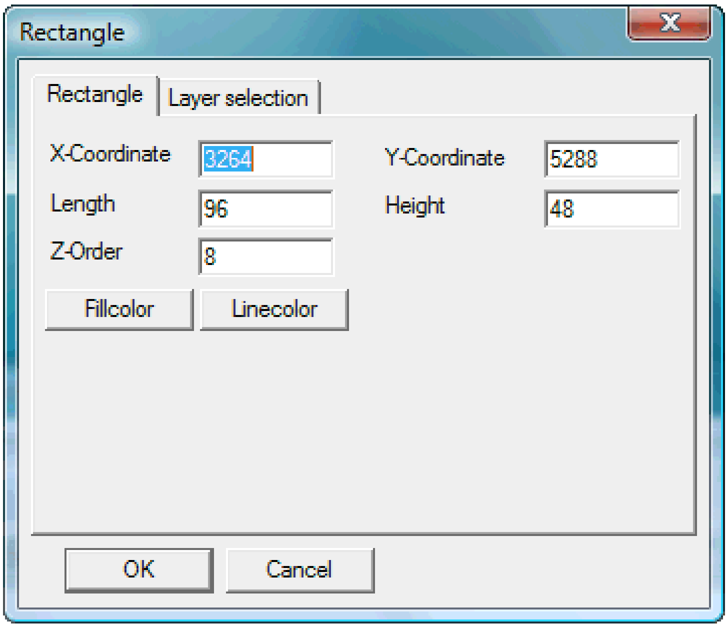


Figure 5.2 Dialog-box of a rectangle

With the help of the button "Fill color" you can set the background color of the element. By using the button "Line color" you can edit the color of the frame line of the element

If graphical elements are added in a model window, they will be stacked automatically on a unique level. The pile sequence is recognizable if elements overlap or do not appear at all. You are able to move a single element or a group of elements inside the stack, e.g. you can move objects inside the stack one level up or down by selecting the element or group of elements, then click the element with the right mouse button and select "Foreground" or "Background" from the context menu. Another way to change the position of an element inside the stack is to change the value of the "Z-Order" in the elements dialog-box. Each Z-order number is assigned to one graphical element inside the model. Z-Order number "1" is assigned to highest level in the foreground.

In order to achieve special effects, you can arrange elements so that they overlap and produce shadow effects.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

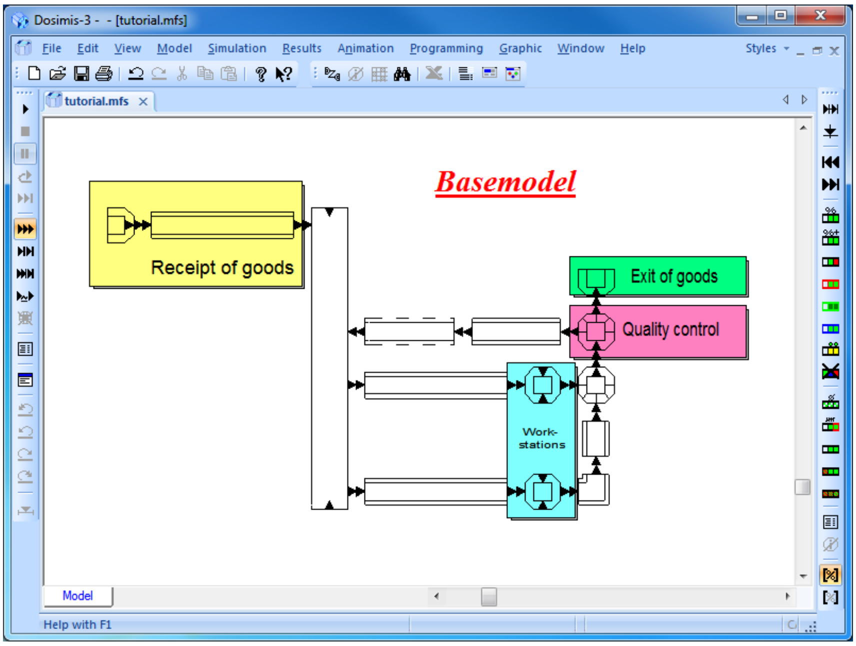


Figure 5.3 Completed layout including graphical comments

6 Summary: Data of the Study

6.1 Model Parameter

Source:	Objects are generated randomly:	Type 1 and 2 with same frequency (50 : 50)
	Distribution of output time:	normally distributed: mean 60 sec, standard deviation 5 sec
Accumulation Conveyor:	Conveying speed:	0.2 m/sec
	Length of segment:	1 m
	Capacity:	- after the source: 10 parts
		- before workstations: 2 parts
		- after workstation “Below”: 1 part (edge conveyor - forward control)
		- after edge conveyor: 4 parts
		- feed back conveyor: 3 parts
Shuttle:	Loading path:	1.1 m
	Unloading path:	0.1 m
	Loading/unloading speed.:	0.2 m/sec
	Slowly driven path:	0.5 m
	Speed fast:	1.0 m/sec
	Speed slow:	0.1 m/sec
	Right-of-way strategy:	Priority to receipt of goods
	Distribution strategy:	destination with (object type)
	- Object types:	1,10 work station above
		2,20 work station below
	Position parameter:	- Entrance 1: 0 m (receipt of goods)
		- Entrance 2: 15 m (feedback)
		- Exit 1: 20 m (to workstation “Above”)
		- Exit 2: 25 m (to workstation “Below”)
Workstation:	Length:	1 m
	Speed:	0.2 m/sec
	Working time:	normally distributed mean 80 sec, deviation 5 sec
	Quota of rework:	15 %
	Set-up time:	60 sec (with each change of type)
Combining station:	Conveying path:	1 m
	Speed:	0.2 m/sec
	Right-of-way strategy:	FIFO
Distributor:	Conveying path:	1 m
	Speed:	0.2 m/sec
	Distribution strategy:	destination with (object type)
	- Object types:	1,2 to the sink,
		10,20 to the feedback conveyor
Sink:	Distribution of departure time:	exponential distributed, mean 55 sec

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

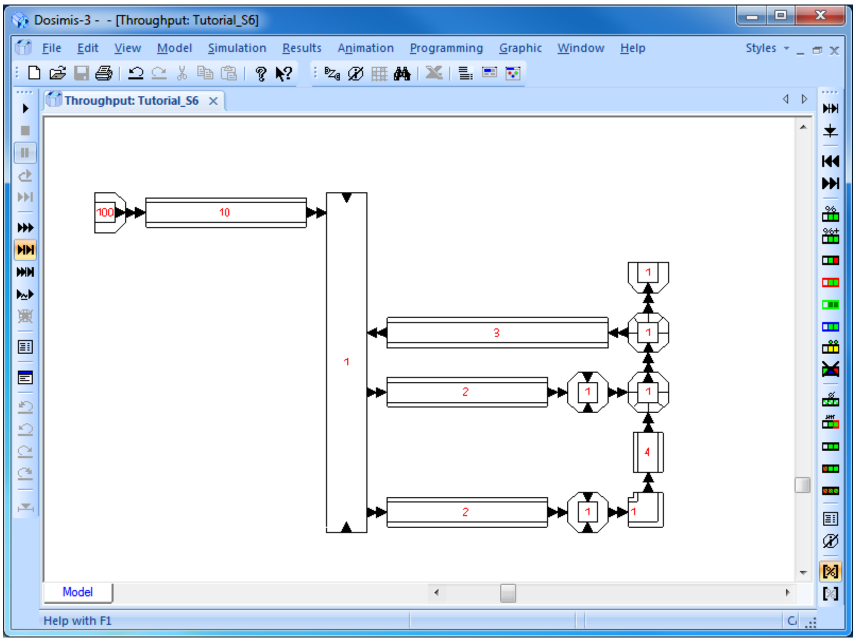


Figure 6.1: Module capacities

In order to enable or to disable the display of module capacity, please select **Model/Info…/Capacity of elements** from the menu bar.

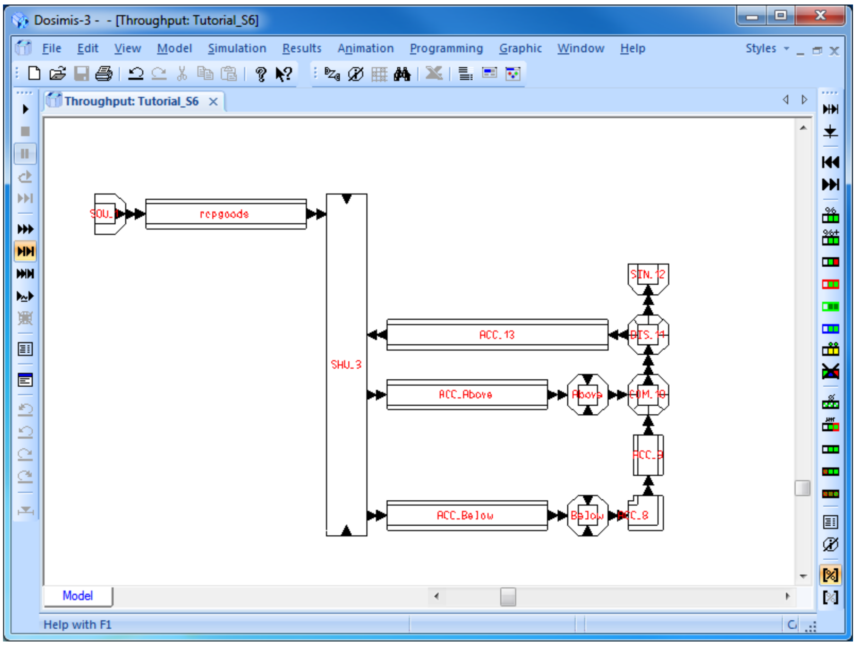


Figure 6.2: Module names

In order to enable or to disable the display of module names, please select **Model/Info…/Names** from the menu bar.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

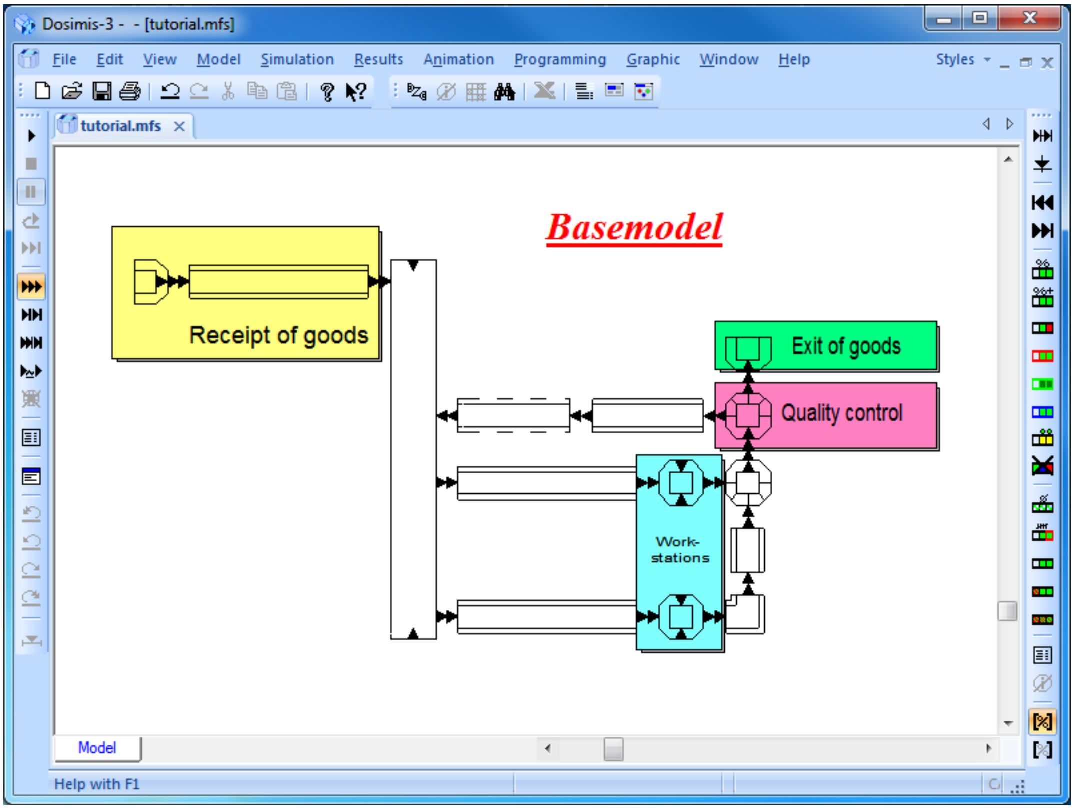


Figure 6.3: Final layout after optimization

6.2 Summary of all Simulation Runs

Step	***Characteristics***	***Measure***
1	Deadlock	Changing the entrance priority of the shuttle. High priority to feedback conveyor.
2	Presorting	Increasing the size of buffers before workstations from 2 parts to 4 parts.
3	Decoupling	Further increasing of buffer sizes before workstations up to 10 parts. Decoupling between shuttle and workstations.
4	Increase of shuttle speed	Increase maximum speed of the shuttle to 2 m/sec.
5	Disposal preferred	The distributor after workstation “Above” prefers to dispose the material flow out of this work station (Priority 1 to the entrance connected to this work station).
6	Buffer before the sink	Inserting a buffer before the sink (with a capacity of 10).
6a	Prolongation of simulation time	Simulation time doubled to 600 min.
7	Minimizing of set-up time	Inserting of a bulk conveyor to form lots in the feedback wing (including a small preliminary accumulation conveyor).
8	Mitigation of the sink	Changing the type of departure time distribution from “exponentially distributed” to “normally distributed” keeping the same mean and setting deviation to 5 sec.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

9	Decrease of buffer size before the sink	Decreasing the buffer size to 2 parts.
10 a)	Decrease of buffer size before work stations	Decreasing the size of both buffers to 8 parts.
10 b)	Further Measures	Further decrease of buffer or lot size.
11	Factory tuning	Decrease of cycle times of about 20 % (Source 48 sec., Sink 44 sec.). Rework is sent to the sink.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

7 Introduction to the Tutorial (Part 2)

7.1 Structure of the Tutorial

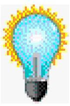
By the first part of the Tutorial the user shall be enabled to create the planed simulation models, to edit parameters and to modify the model structure by himself. Part 2 of the Tutorial is a short overview of further functionalities as well as special module groups of DOSIMIS-3.

Part 2 of the Tutorial is divided to following chapters:
1. Structure of the Tutorial
2. Faults and Breaks
3. Work Areas, Workforce

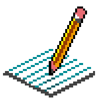
This Tutorial is to facilitate the understanding in further functionalities of DOSIMIS-3 for you. However, please do not expect all functionalities of individual addressed topics to be explained in completeness. The Tutorial does not replace the user's manual. This would go beyond the scope of this Tutorial. User's manual/Online help and the Tutorial can help you to assimilate enough knowledge about DOSIMIS-3 to be able to use it without any training.

7.2 Icons

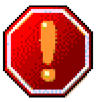
In order to facilitate orientation in this Tutorial for you, we arranged the text into sections of special functionality and marked these by appropriate symbols or icons. The following icons are used:



Examples or steps that may help you to find your way when using DOSIMIS-3.



Please pay attention to this important notes, which are marked by this icon.



Attention: this icon indicates a warning. The facts described in this section lead easily to errors, problems and deadlocks.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

8 Failures and Pauses

8.1 Task

In part 1 of the Tutorial the model of a small production system was analyzed. In continuation of this example now the modeling of failures and pauses is supposed to be explained.

During operation it was determined that faults occurred at both work stations frequently. This faults reduced the utilization to 95 %. Furthermore the records proved that the average downtime was at 5 minutes. In a further analysis it is to be examined whether the plant is able to achieve the requested throughput in spite of this performance loss.

8.2 Theory

The following chapter shows to you how to reproduce failures resp. pauses. The parameterization of failures and pauses is completely identical. The distinction is only used for separate statistical recording of component standstill times.

Failures and pauses can be parameterized for all modules and module groups. These may be operational interrupts as e.g. break, shift changeover, group discussions, set-up and cleaning times or unpredictable faults. Additionally rejects resp. rework as well as logistic failures can have big influence on the system. All these can be reproduced as failures too.

The “time between failure (MTBF)” and the “time to repair (MTTR)” of an interrupt are determined in each case according to a selectable kind of distribution. The “time between failure” describes a time interval between the end of one fault and the beginning of the next fault. The “time to repair” designates the duration of a fault.

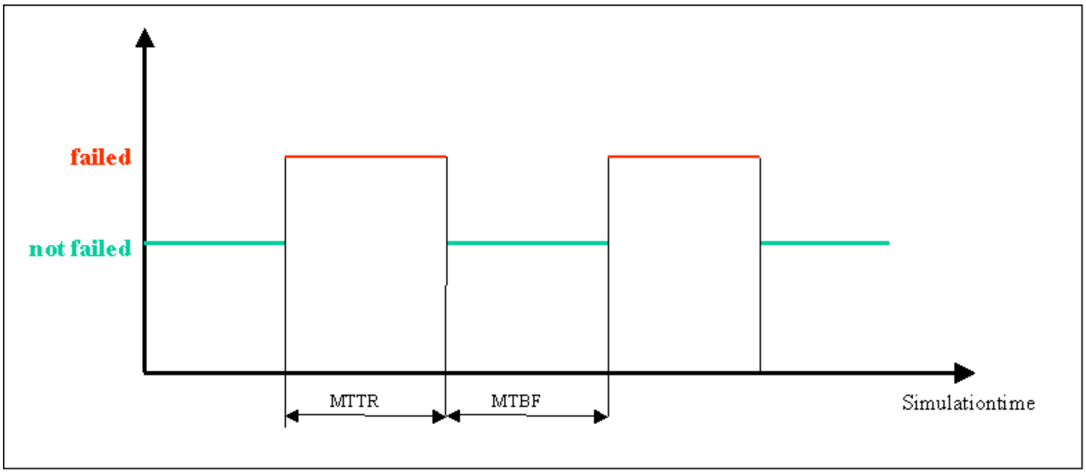


Figure 8.1 “Time between failure” and “Time to repair”

Thus the availability results:

$$Availability = \frac{MTBF}{MTBF + MTTR}$$

Figure 8.2 Availability

The “time between failure” is calculated from the “mean time to repair” and the “availability”:

$$MTBF = \frac{Availability * MTTR}{1 - Availability}$$

Figure 8.3 Time between failure

Regarding an availability of 95 % and a “time to repair” of 5 minutes a “time between failures” of 95 minutes results.

8.3 Including of Failures in the Simulation Model

The availability of work station “above” shall be 95 %. The work station shall fail in irregular time intervals. The fault is supposed to be reproduced randomly (stochastic) and not in fixed time intervals. The “mean time to repair (MTTR)” is “exponentially” distributed with an mean value of 5 minutes.

The “mean time between failures (MTBF)” will be normally distributed with a deviation of 10 % and a mean value calculated as shown above, depending on availability and MTTR.

At first you will be shown how to define a failure resp. pause. Please reproduce a “failure” as described below:

- Open the model „`tutorial2.mfs`“.
- Save the model with a new name as „tutorial2S.mfs“
- Select **“View” → “Controls Palette”** from the menu bar or press the **“F2” button** while pressing the **“Ctrl” button** on your keyboard.

- Select the break symbol (BRK)  from the controls palette and place the module in the work area of your model by click on the left mouse button.
- Please select **“Model”** → **“Linking active”** from the menu bar or press the **“F9”** button on your keyboard to activate the linking mode.
- First click on the break module with the left mouse button to select the module. The selected break module is displayed in blue color now. Then click on the module or group of modules to be failed. Modules that are connected to the selected break module will be displayed in red color in linking mode.
- At last deselect linking mode and save your model.

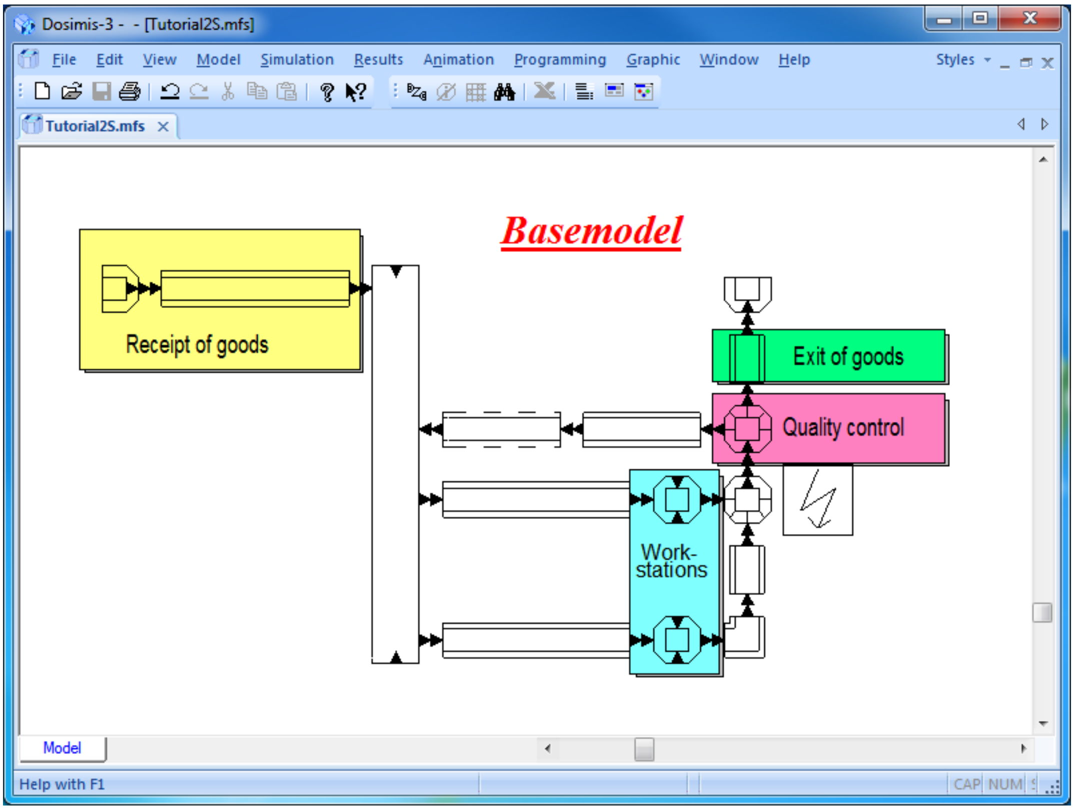


Figure 8.4 Linking work station to break module

8.4 Editing of Failure Parameters

Now the parameter of the failure can be entered. Double-click on the break module to open the parameter input mask.

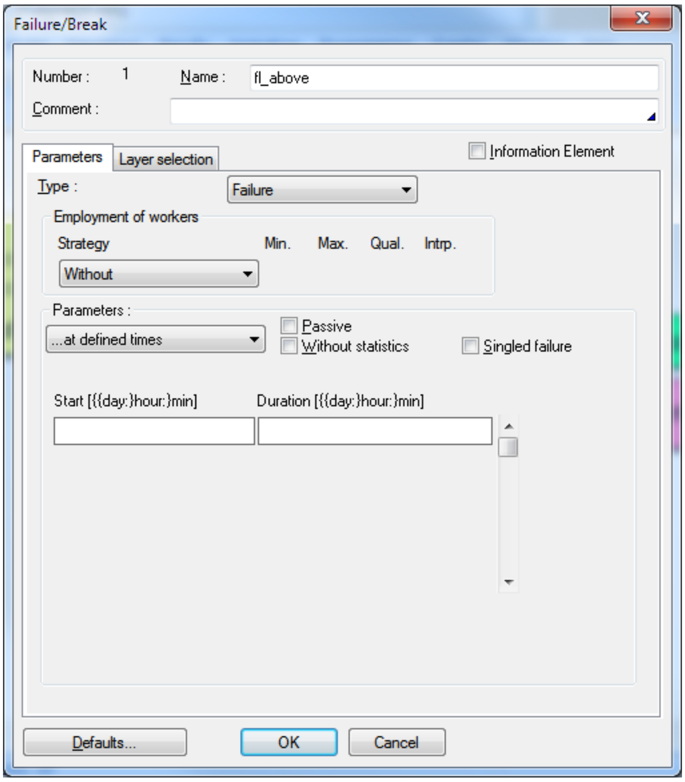


Figure 8.5 Parameter input mask of Failures /Pauses

To define the kind of break (**failure/pause**) select the according “type” from the combo box. No “employment of workers” is planned.

- Rename the break as “fr_above” (default: BRK_1).
- There are several kinds of failure that you can select from the “failure” combo box. Select **“…at random”** from the “failure” combo box.
- Now select **“normally distributed”** from the “MTBF” combo box and enter 5700 sec as “mean” and 570 sec as “deviation”.
- Then select **“expo. distributed"** from the “MTTR” combo box and enter 300 sec as “mean”.

Finally the parameter input mask of the failure module looks like following:

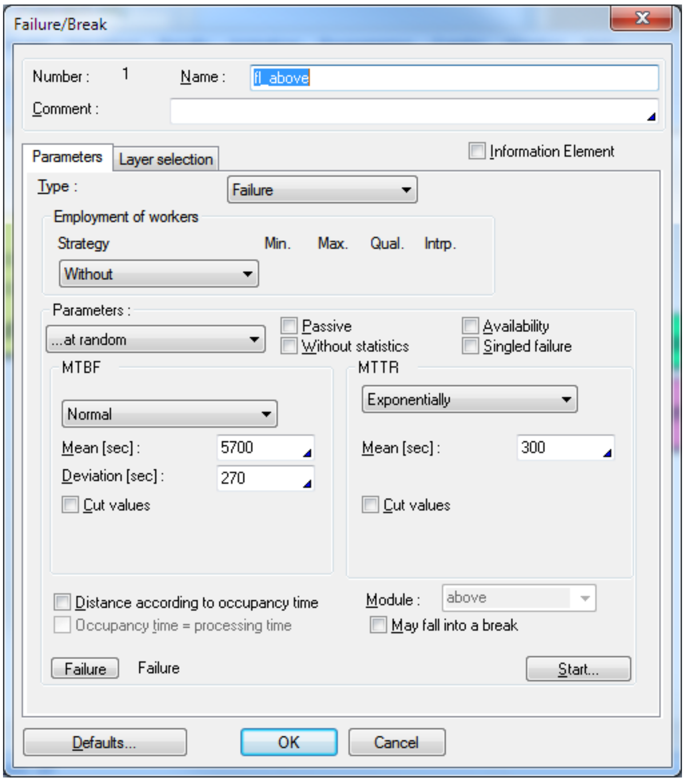


Figure 8.6 Completely filled out parameter input mask of the failure

Checking the failure parameters by using the “failure” button on the parameter input mask (available only for failure “…periodically” or “…at random”).

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

When using the "Availability" function DOSIMIS-3 will calculate the mean value of the "MTBF" according to the entered availability:

- Enter the "MTTR" parameters as described before.
- For "MTBF" enter the value of "1" as "mean" and as "deviation". This is necessary to avoid any consistency check error.
- Select the check box called "Availability" and enter the desired value (e.g.: 95) into the "Availability[%]" input area.
- Now deselect the "Availability" check box. As a result the calculated "mean time between failure" is displayed inside the input area called "mean[sec]".

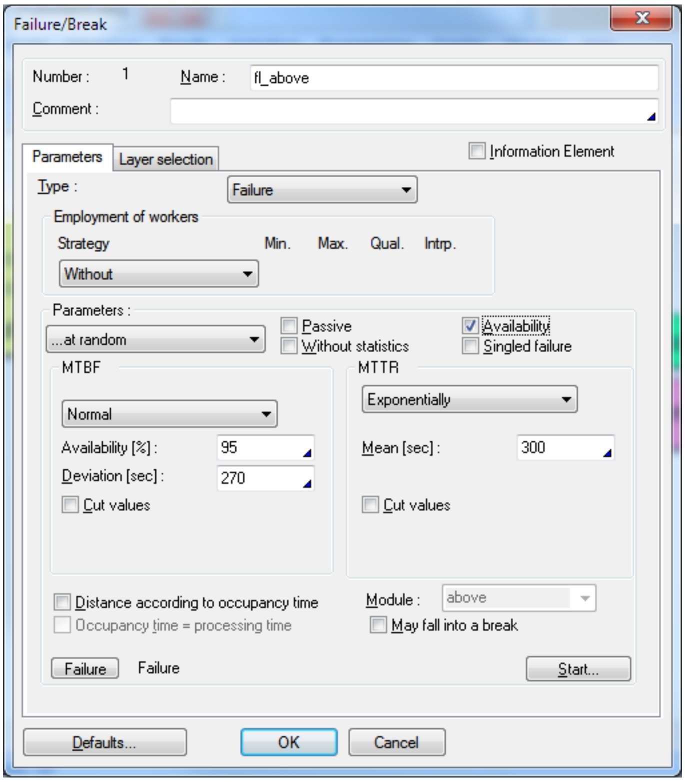


Figure 8.7 Determination of MTBF by using the availability check box

8.5 Analysis of Failures

After the simulation run is completed, you can start the animation and watch the movement of objects inside the model. Please select **"View"** → **"Tools"** → **"Animation-toolbar"** from the menu bar to activate the animation-toolbar in your DOSIMIS-3 window. Then click on the button *"time factor"* on the animation-toolbar and start the animation by click on the *"start"* button. The first failure occurs after about 1,75 hours.

While a module is failed, it is displayed in red color.

While a module is paused, it is displayed in blue color.

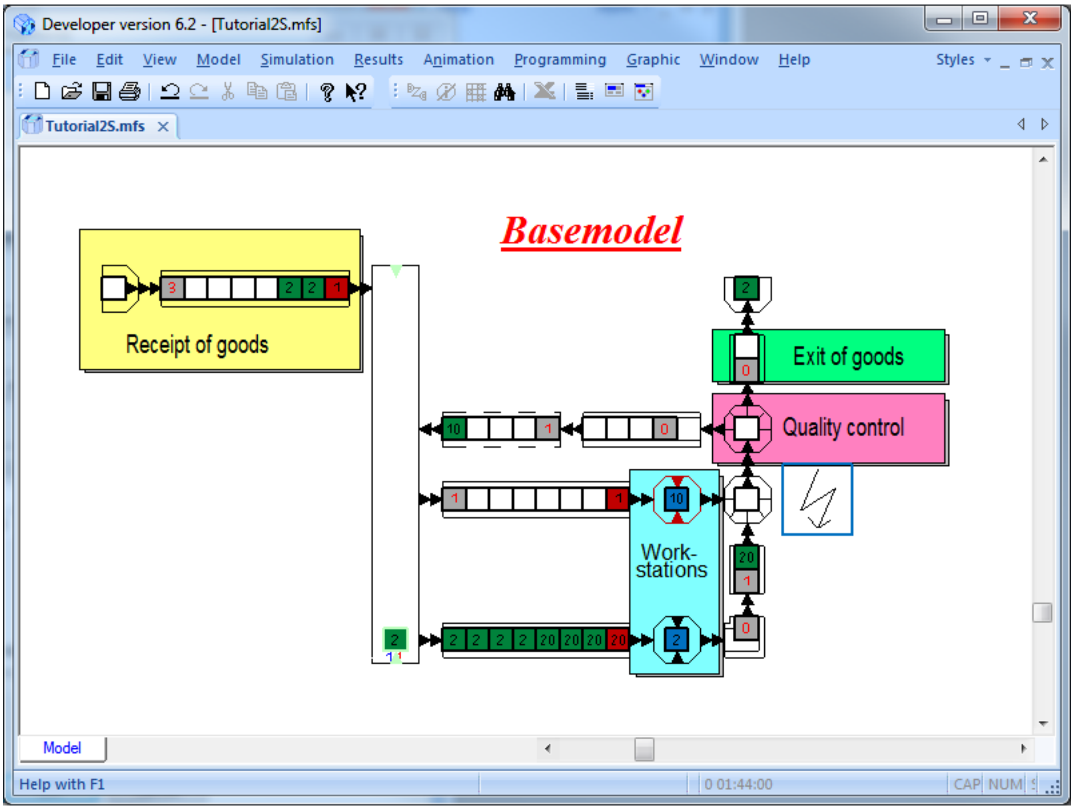


Figure 8.8 Animation

If a failure occurs all processes of the assigned modules are stopped. It is possible to consider the state or failure of one module for strategy decisions of other modules.
If a failure appears after a strategically decision has been done (e.g. distribution strategy), this decision will not be changed afterwards, that means that the object has to wait until the failure disappears.
In DOSIMIS-3 it is possible to assign one module to several break modules, especially if the user wants to separate between failures and pauses or if different kinds of failure shall be considered. These may overlap what is according to the theory of random distributions.
Failures are unpredictable interrupts, on the other hand pauses are planned. The frequency of both kinds of interrupts can be determined by the separate data collection. If a module is failed and paused at the same time, then the time of

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

overlap is imputed to failure time.

Please first select work station “above” by mouse click and then select **“Results” → “State diagram”** from the menu bar to open the state diagram window. As you can see a failure appears about 100 minutes after start. There are no further activities until to the end of this failure. The failure has to be finished before a new object is allowed to enter the module and will be processed.

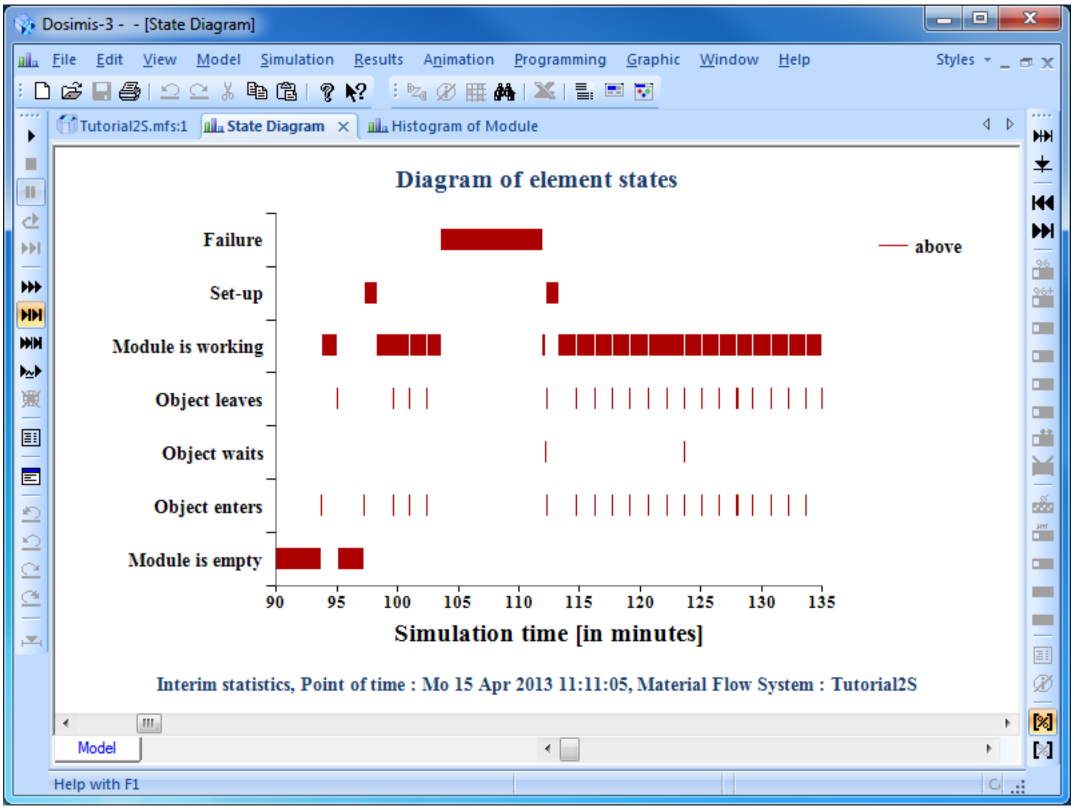


Figure 8.9 State diagram

Now the failure quota, that results from the assigned failure appeared during the statistics period, is displayed in the module histogram too.

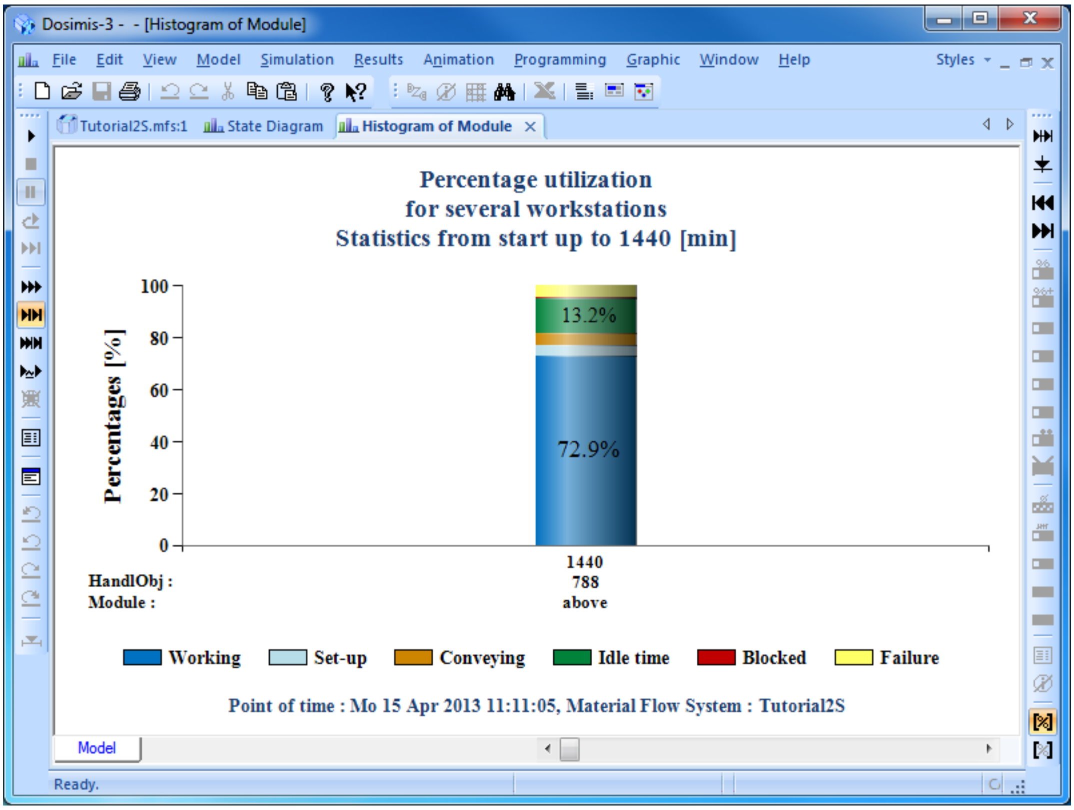


Figure 8.10 Module histogram

8.6 Statistics File

In order to open the statistics file called "*tutorial2s.slg*" please select **"Results"** → **"Statistic data"** from the menu bar. The "Final Statistics" window opens. Use the tree view on the left side of this window to browse for the statistic data you want to see. It is not possible to edit or to copy any data of this file.

The final statistics of material flow system *tutorial2s* gives a global overview on simulation results. Module performance values contain general information like throughput or utilization. A failure related statistic of all modules is to be found as "classification of utilization" of the module type. This displays a quota of failure of about 4.3 % for work station "above".

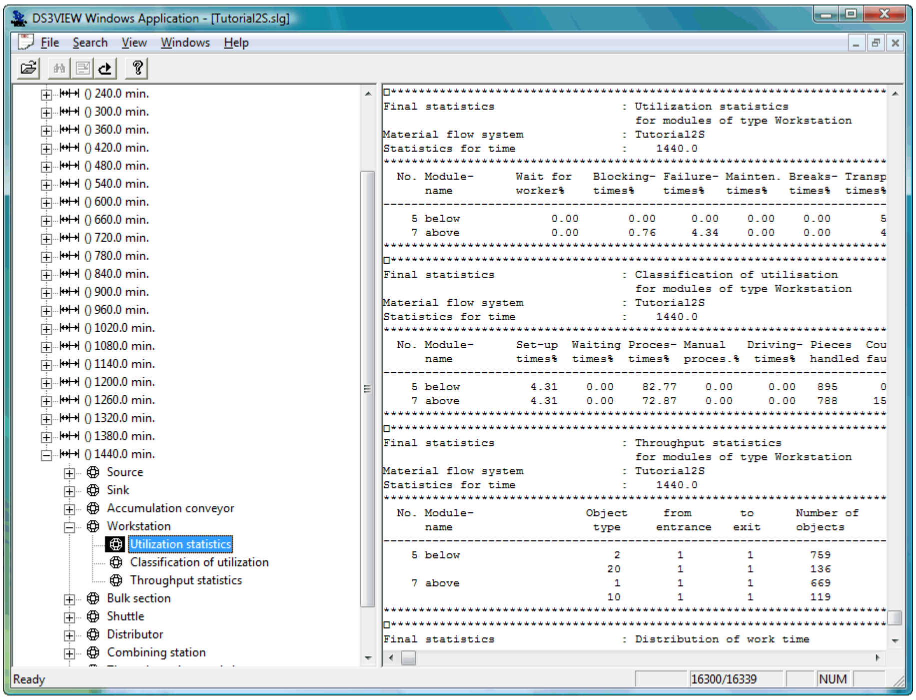


Figure 8.11 Final Statistics (classification of utilization of workstations)

At the bottom of the statistics list you will find the evaluation of duration and interval of failures and pauses. So for the break module "fr_above" the following results are displayed.

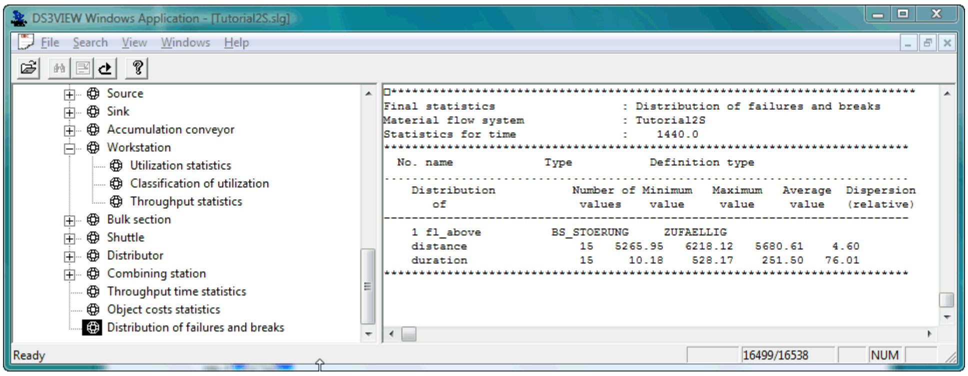


Figure 8.12 Final Statistics (Failures)

The analysis of the defined failure shows however a serious problem. Despite the failure quota was set to 5% the simulation provides a failure quota of 8.53%. The reason for this is to be found in the number of failures that appeared during simulation time. Fourteen faults appeared during this period. The number of events is to small to approximate the chosen distribution of the MTBF and to receive a representative mean time. “Good natured” distributions (such as fixed time, uniformly distributed, normally distributed) will achieve the mean value very soon,. since in best case the mean may be hit after chosen randomly twice. In case of the exponential distribution it is necessary to chose randomly several times to achieve the desired mean value. In our example the maximum chosen value is 1613 seconds. After this value has been chosen, e.g. it is necessary to choose furthermore at least five times to reach the mean value of 300 seconds if the mean value of these five choices is about 38 seconds. The number of at least 50 events is to be regarded as a benchmark for this kind of distributions. Therefore the simulation time in our example has to be increased. The “simulation time” now will be set to 7 weeks and the “statistic interval” will be set to one day. Additionally the “Pre-run” time is set to one day too.

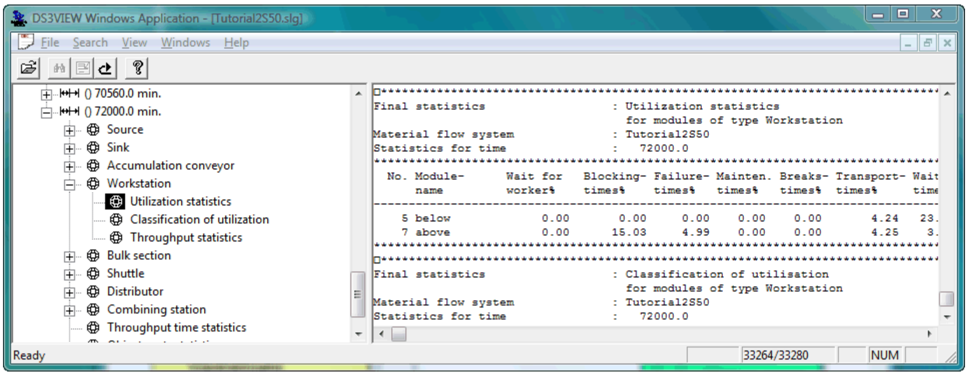


Figure 8.13 Final Statistics (classification of utilization of workstations)

The analysis of failure now results a quota of 4.99% failure. For this 705 events have been considered

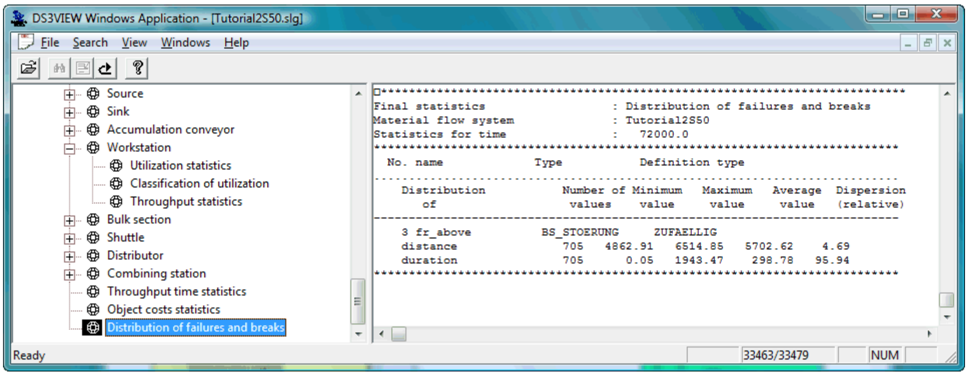


Figure 8.14 Final Statistics (Failures)

8.7 Task

Now also the work station “below” shall be failed

- Please select the break module called “fr_above”.
- Then use the copy function to copy this break module and move it to the favored position.
- Double click on the new break module.
- Enter “fr_below” into the input area called “Name”, and then click on the “OK” button of this module.
- Press the „F9“ button on your keyboard and deselect the module called „fr_above“ by click with the left mouse button on this module.
- Now select module „fr_below“ by click with the left mouse button on this module.
- Press the „F9“ button on your keyboard again to finish connecting mode.

Please select **“Model“ → “Info” → “Connections”** from the menu bar or **click the right mouse button while pressing the “shift” button on your keyboard** to display all links done in the opened model. To display links of the new break module named “fr_below” only, please click with the left mouse button on that module

To hide all links, select again **“Model“ → “Info” → “Connections”** from the menu bar or **click the “Finish View” button** from the „Modeling“ bar.

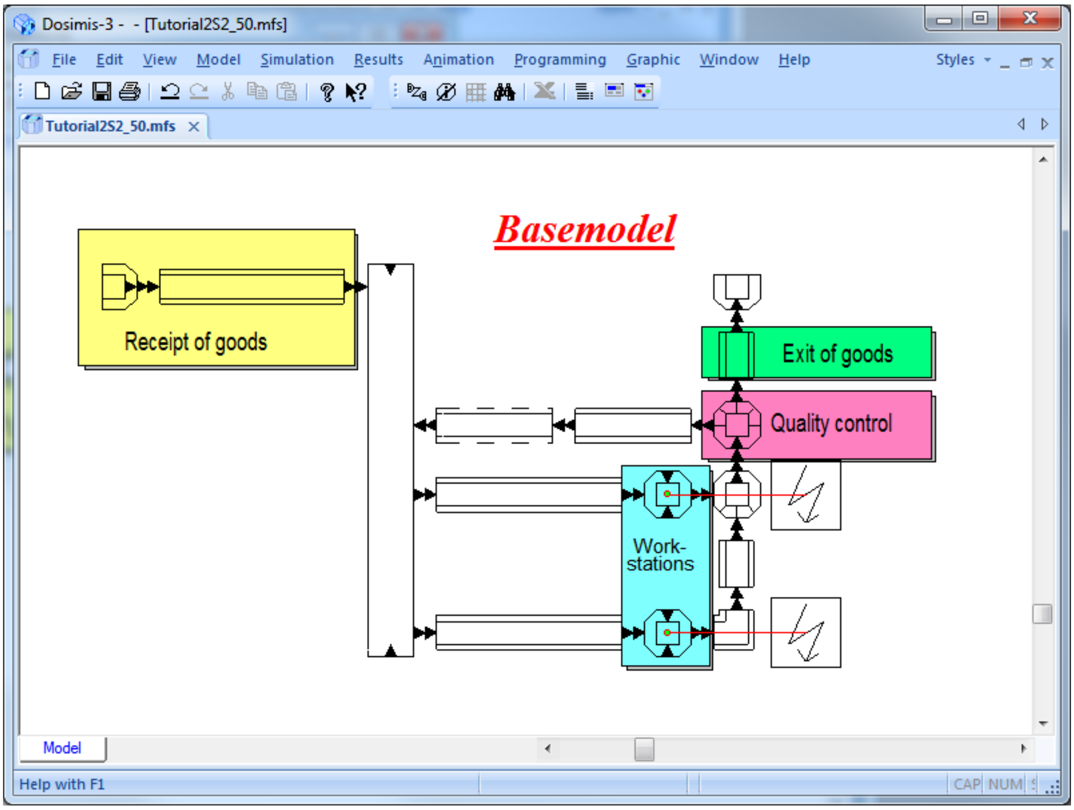


Figure 8.15 Links

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

8.8 Shift Model

For the analysis of large periods often it is reasonable to include the shift model of the real production line as a parameter in the simulation model. So it is easier to determine the time when an effect appears, because it is not more necessary to add shift breaks and pauses to simulation time.

In this example the plant works in a tow-shift operation mode for five days a week. Furthermore all pauses of work time shall be considered in the simulation model, too. During pauses the conveying system and the sink continue to work, but work stations, source and quality inspection are paused. Outside of the shift times all components are to be turned off.

The used Shift model looks like following:

Pause:	9:00-9:15; 12:00-12:30; 16:00-16:15 and 19:00-19:30
Daily work time:	6:00-22:00; on Friday only 6:00-16:30

For a better understanding a reference time corresponding to simulation time „0“ should be specified. In this example the reference time should be Monday 0:00 o’clock. This facilitates the assignment of times in the model.

Three breaks/pauses will be defined in addition. The first break module is to reproduce all daily pauses. A periodical pause will be defined that repeats every day. Start time and duration of all pauses have to be entered into the appropriate input boxes in the failure area of the break module parameter mask. Because start of period is 0:00 o’clock all the start times of pauses match the real times, no offset has to be added. Please regard to enter the duration and not the end time of the pause. Only work stations, the source and the quality inspection station are to be connected to that break module.

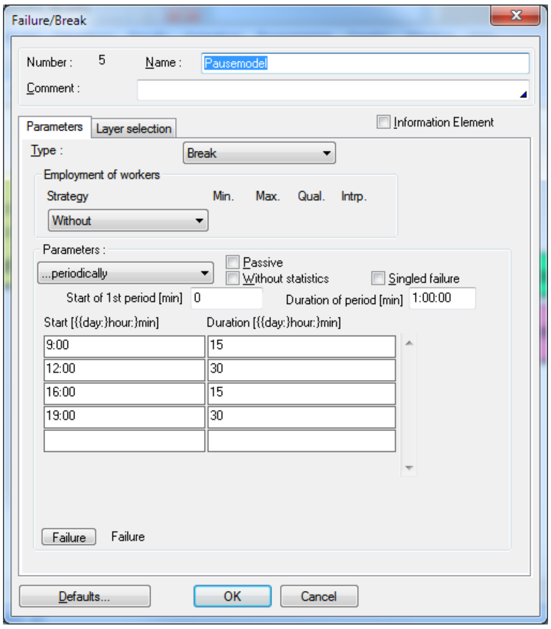


Figure 8.16 Shift Model of Pauses

The second pause is periodical, too. This pause reproduces the daily shift model. So only the first 6 hours from 0:00 to 6:00 o’clock and the 2 hours from 22:00 to 24:00 o’clock have to be

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

defined as pauses that stop the plant. This break module has to be connected to all modules of the model.

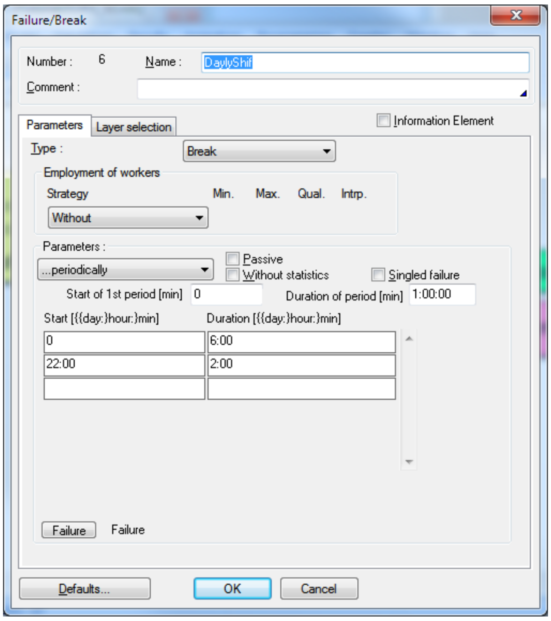


Figure 8.17 Shift Model of daily work time

The third break module reproduces a periodical pause with a period time of 7 days. In this module the pause starts on the 4^{th} day at 16:30 o'clock and lasts to the end of the period (duration = 2 days, 7 hours and 30 minutes). Monday is day number "0", so Friday is day number "4". This break module has to be connected to all modules of the model.

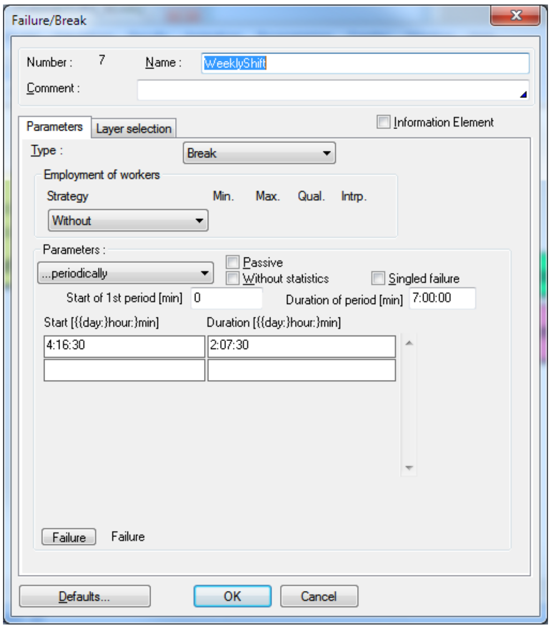


Figure 8.18 Shift Model of weekly work time

After a new simulation run, the behavior of the simulated plant is to be analyzed. To use minutes as scale for the x-axis in statistic data appears not to be reasonable, because simulation time is about 50 days now. So it might be wise to use bigger units instead. For this,

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

please select **“Results“ → “Result Parameter”** from the menu bar, click on the **tab “X-axis”** and select the **check box** named **“Time[DD:HH:MM]”.** Now click on the **tab “Selection**” and make sure that the **check box** named **“Intervalstatistics”** is selected**.** Then click on the **“Accept” button** and close the “Result Parameter” window by click on its **“Exit” button.** In diagrams the time unit of the x-axis now is changed to **“Day:Hour:Minute”** (DD:HH:MM).

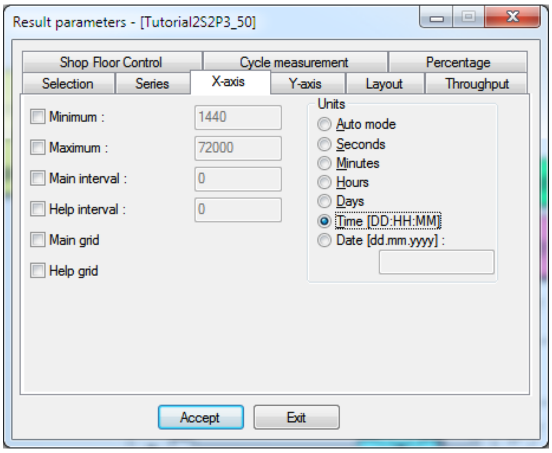


Figure 8.19 Result Parameter

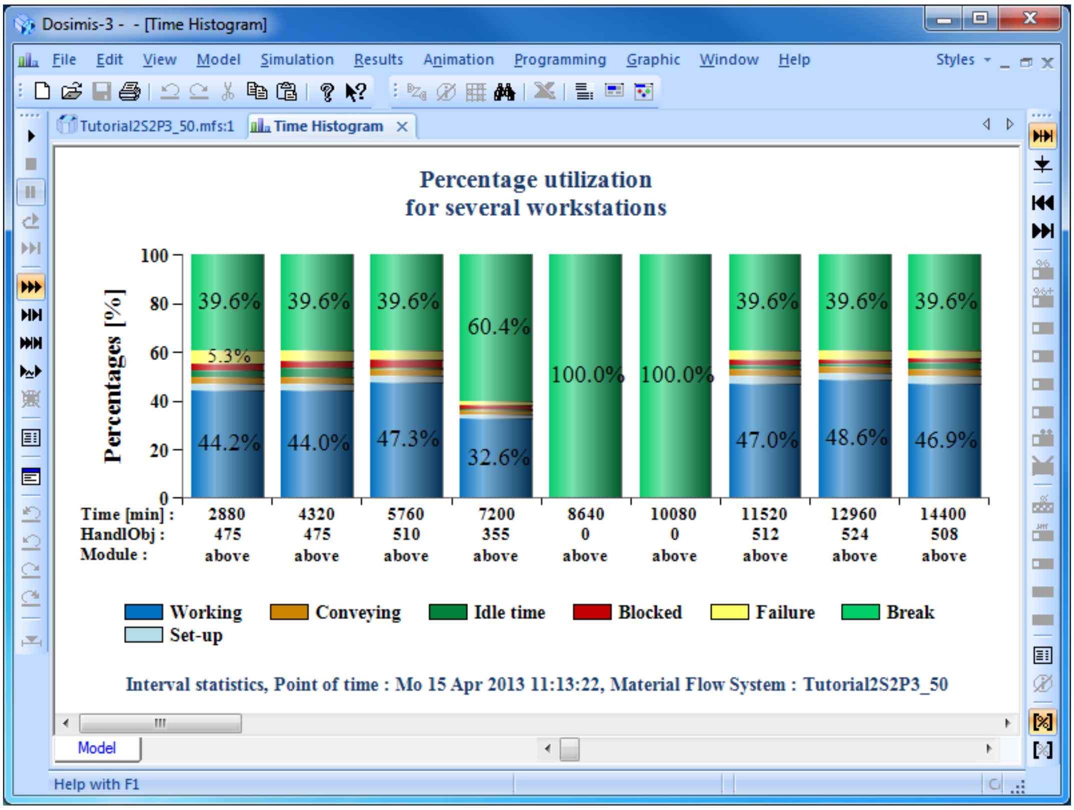


Figure 8.20 Statistic with Shift Model used

To display the diagram shown in Figure above, please select **“Results“ → “Time Histogram”** from the menu bar. Please use the “scroll bar” at the bottom of that window to browse along the time axis. It might be fretful that a lot of pause times appear in that diagram

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

during the considered period. So a big portion of time is displayed as pauses. To eliminate pauses out of statistic calculations, in DOSIMIS-3 it is possible to filter statistic data of the regarded time period.

8.9 Filter Failures and Pauses out of Statistic Data

In a DOSIMIS-3 model you are able to filter times of failure or pause out of statistic data.
Double click on the break module to be filtered.
Select the check box named **"Without statistic"**.
Click on the "OK" button to close that break module and start simulation again.

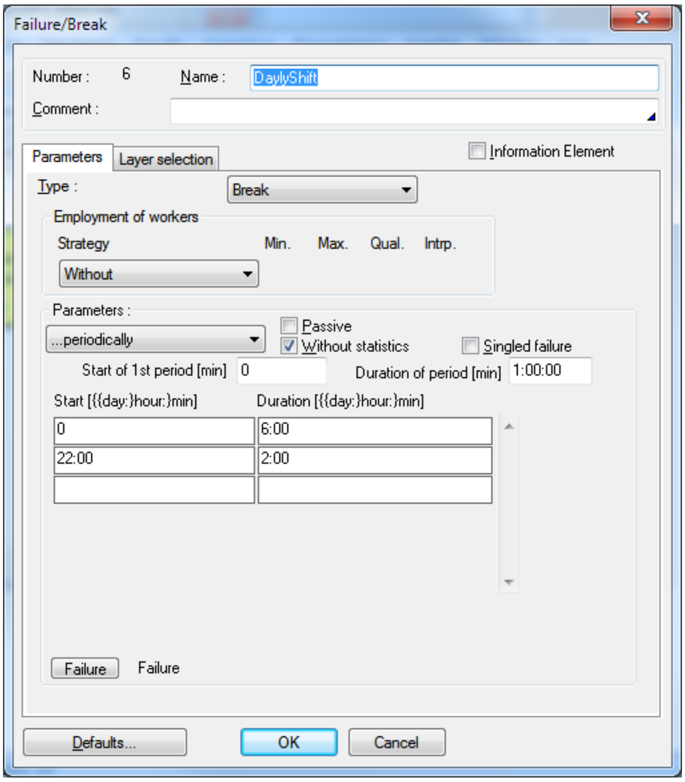
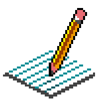


Figure 8.21 Activate Filter for statistic data in a break module



In that example the shift model of daily and weekly work time is to be filtered. Now the portion of failure or pause is displayed as a thin bar (named "without stat.") on the left side of the main bar in the "Module Histogram".

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

Take a look at the “Time Histogram” of the work stations again after simulation is completed. The two blocks without statistics are remarkable. These blocks represent weekends of the simulation period. Weekends are filtered out of statistic data. The day before, the portion without statistics is higher than to the remaining 4 days, since on Friday work time ends at 16:30 o’clock.

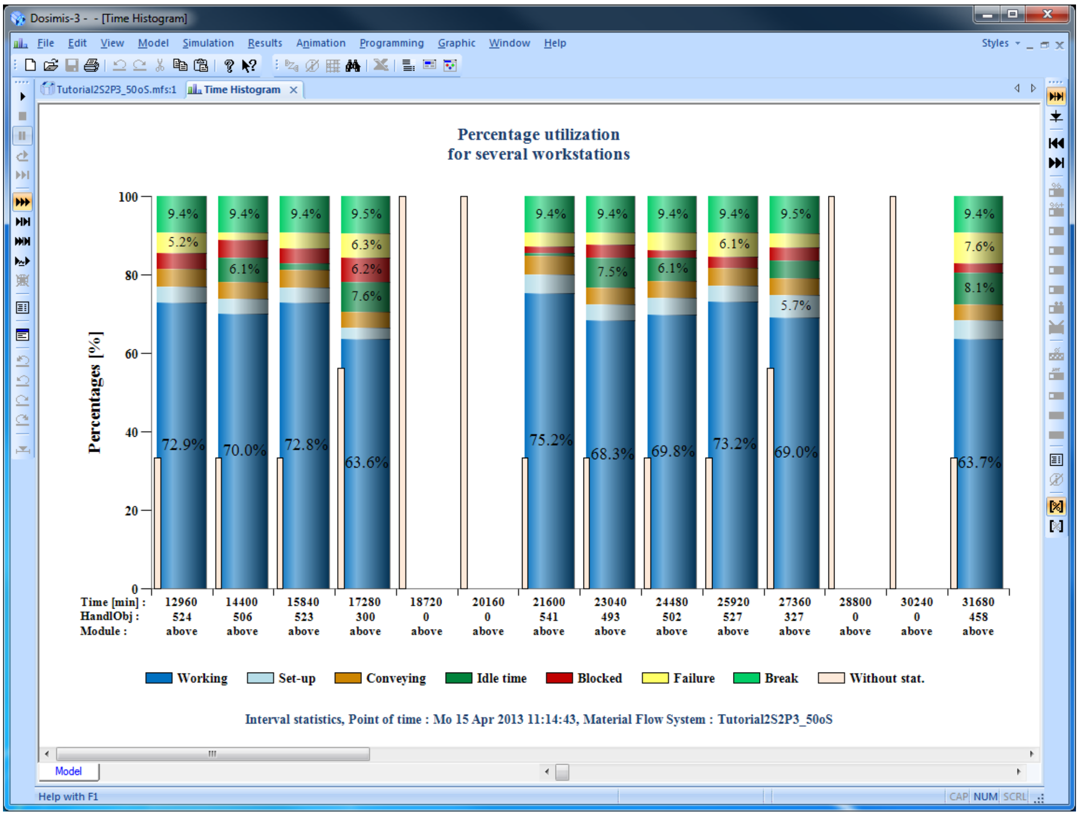


Figure 8.22 Module Histogram with statistic filter activated

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

The following diagram is to clarify again what it means to filter break times out of statistic data. 33,33% break time per day (8 of 24 hours) and 50% work portion per day (12 of 24 hours) connote, since the plant runs only for 16 hours a day, that in reality the work portion results to 75% of the running time (12 of 16 hours).

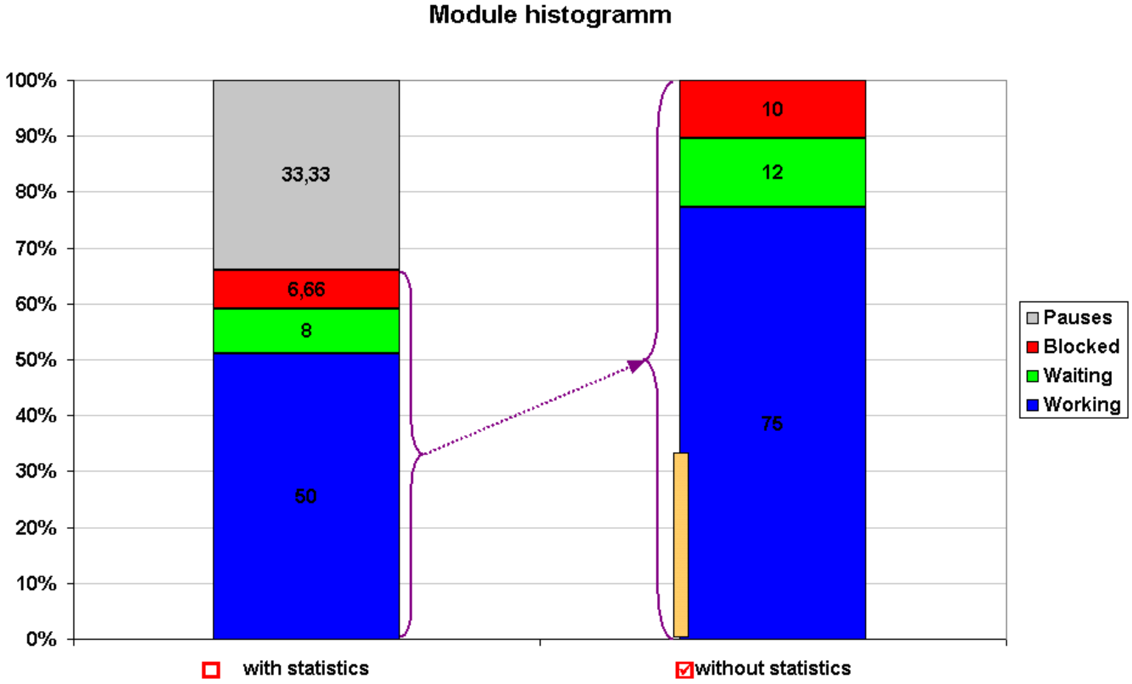


Figure 8.23 Conversion "with → without" statistic of break modules

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

8.10 Disable Failures

You can disable either a single failure (break module) or all failures together global, without deleting any break module. This may help you validating the model during modeling phase.

8.10.1 Disable a single Break Module

Double click on the break module.
Select the check box named **“Passive”.**

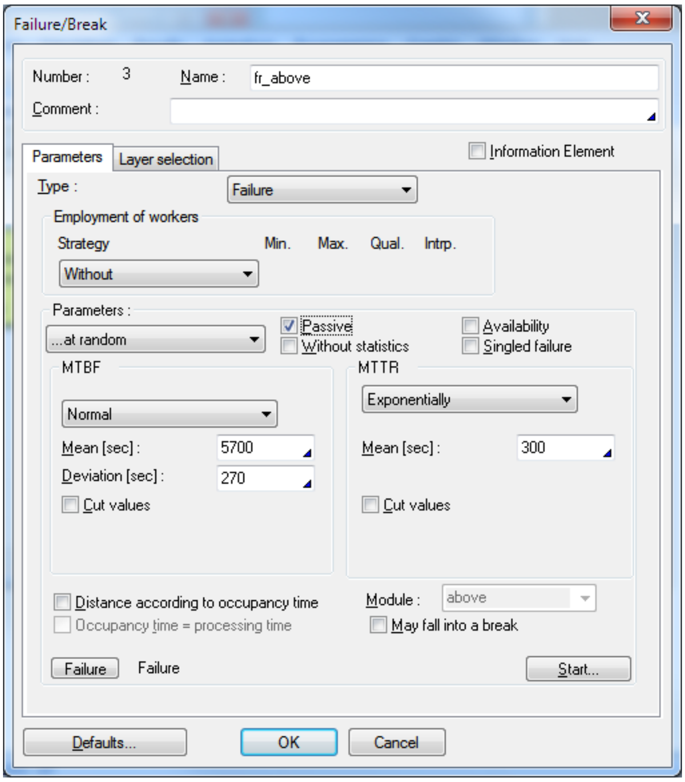


Figure 8.24 Disable failure “fr_above”

8.10.2 Disable all Break Modules global

Select “**Simulation**“ → “**Parameter**” from the menu bar.
Select the check box named “**Disable failures**” and close the “Simulation parameter” window by click on its “**OK**” button.

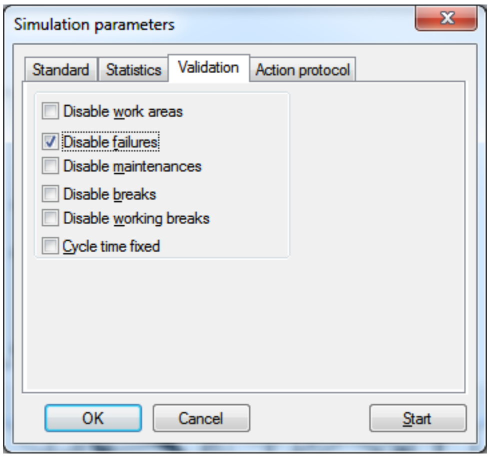


Figure 8.25: Disable all Failures global

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

9 Work Area

9.1 Theory

In order to achieve important optimization goals and results by using DOSIMIS-3, worker employment concepts, group work and multi-machine operation are applied with consideration of quality characteristics, task assignments and shift models. Additionally “work areas” allow a detailed analysis of a kanban controlled job shop production resp. consignment or assembly systems.

Applying work areas the user is able to define tasks that are accomplished in the real system by workers.. This may concern manual treatment of objects in work stations, maintenance work, fault clearance, set-up activity and other general tasks. Recently worker employment can be analyzed exactly with help of work areas.

The special module named **“work area”** is used to reproduce worker in a simulation model. Even different skills and different numbers of workers can be regarded. If a module requests workers, they will be provided to the module by a “work area” if possible. Further the processing sequence can be given as a function of priorities. Also the distance time, that a worker needs to walk from one workstation to another, can be considered for all possible mating of work stations. The default of work breaks can be defined similarly to failures/pauses.

In order to reproduce workforce in a model, following premises have to be fulfilled:

- A module of type “work area” has to be placed inside.
- Every module that may request workers from this “work area” has to be linked (connected) to it.
- A module can be assigned to several “work areas”.
- A “work area” can be assigned to several modules.

9.2 Task

As continuation of the work on the optimized Tutorial model of the first part, a “work area” including one “worker” is to be reproduced. The worker is supposed to work on objects at work station “above” and to set-up work station “below”.

The distance time between regular work place (this is the place, where the worker waits, if no work is present) and the work places amounts to 30s in each case and the distance time between work places is about 10s. After object treatment at work station “above” the worker should wait for 6s, to afford a further object to enter the work station. Additionally a pause model is to be defined for the worker.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

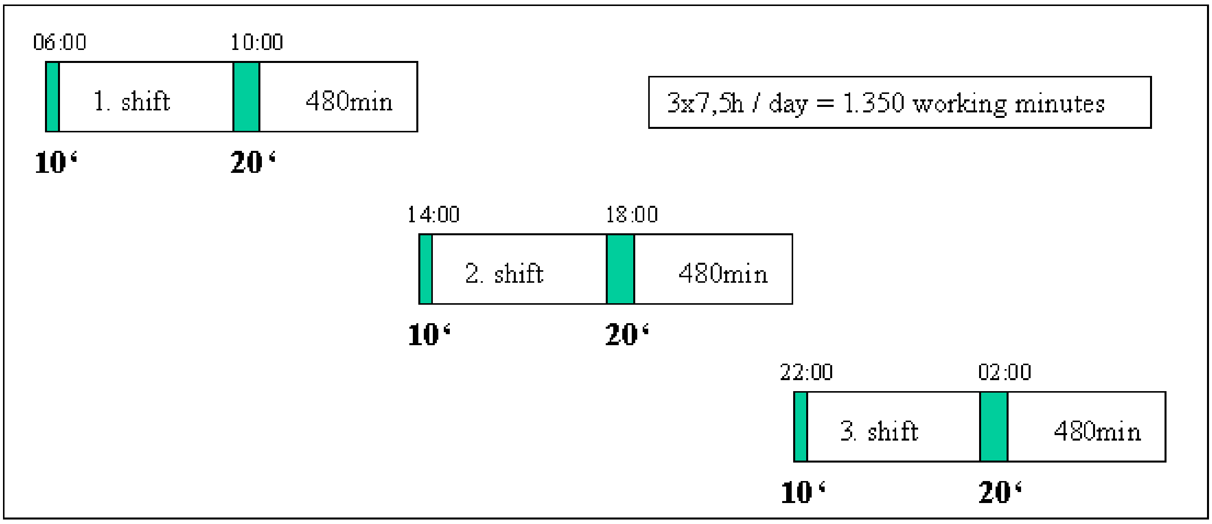
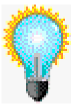


Figure 9.1: Pause model



Please create a “work area” according to following instructions.

- Please open the model **Tutorial2.mfs**. Note! This is not the final model of the previous chapter, but the basic model.
- Save this model using the new name “Tutorial2A.mfs“.
- Select **“View“ → “Controls Palette”** from the menu bar or press the **“F2” button while pressing the “Ctrl” key** on your keyboard..
- Select the “Work area” symbol  on the “Controls Palette” and place it inside the opened model window by click on the left mouse button.
- Select **“Model“ → “Linking active”** from the menu bar or press the **“F9” button** on your keyboard to enable “linking mode”.
- At first the work area has to be selected by click with the left mouse button. The symbol color of the selected module turns to blue.
- Now select the work stations. These will turn their display color to red, what means that these stations are connected to the blue displayed work area.
- Disable “linking mode” by pressing the **“F9” button** again.
- Select the “Working place” symbol . on the “Controls Palette”.
- Place the “Working place” (circle) close to work station “above” by click on the left mouse button.
- Select **“Model“ → “Linking active”** from the menu bar or press the **“F9” button** on your keyboard to enable “linking mode” again.
- Select the “Working place” by click on the left mouse button. It will be displayed in blue color then.
- Now click on work station “above”, then click on the “work area” while pressing the **“SHIFT” button** on your keyboard
- In the animation of the “Working place” only personnel from that work areas is animated, that are connected (linked) with the “Working place”.
- Disable “linking mode” by pressing the **“F9” button** again.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

- Please insert another “Working place” close to work station “below” and connect it to this work station and to the work area as described above.

Often it is favorable to place all components first and to define the connections afterwards. The proceeding is left to the user.

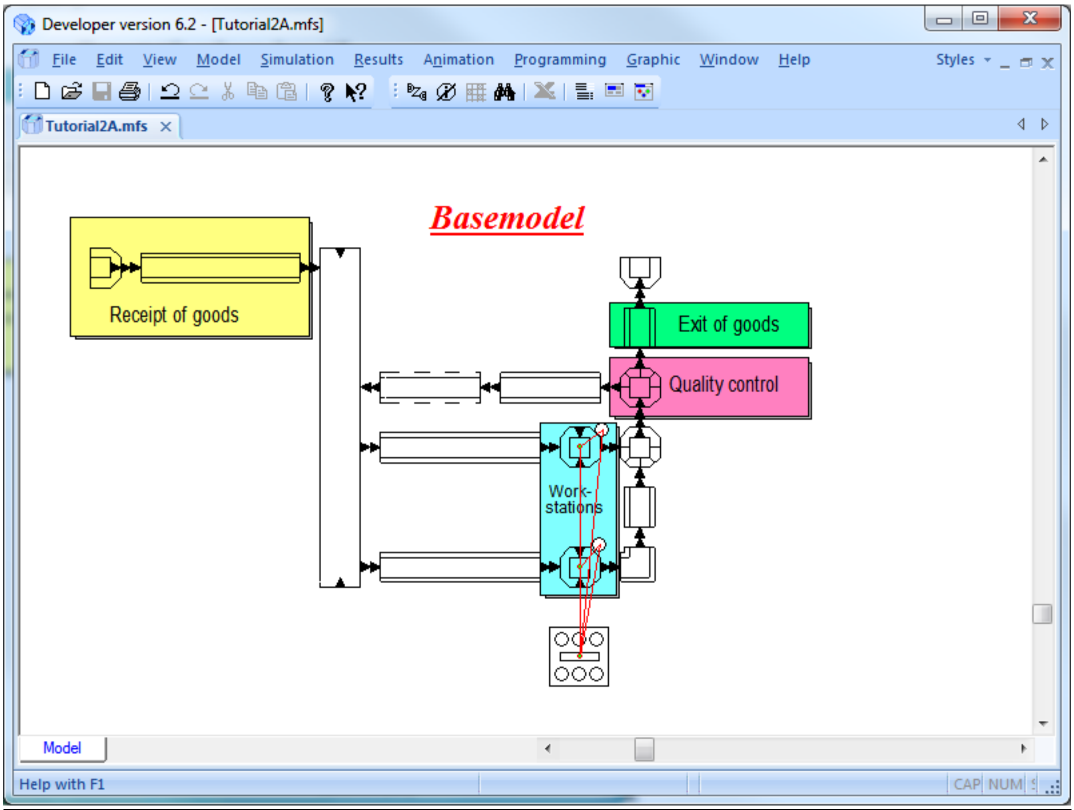
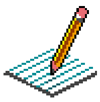


Figure 9.2: Links between modules and work area



- If a module was connected to a work area by mistake, so proceed please as follows to remove this link: Enable (if necessary) “Linking mode” by pressing the “F9” button, select the work area by click on the left mouse button (=> blue) and click on the appropriate module. Its color will change from red to black.
- Furthermore it is possible to assign as many worker positions (Working places) to a module as desired.

9.3 Parameter Setting of Work Area

Setting of parameters of workers consists of the setting of parameters of the modules at those the workers are to work and the setting of parameters of the work area. Settings of the work stations have to be changed in such a way that they request workers. So e.g. for object type 1 it has to be defined, that a worker is necessary for object treatment at work station “above”. This definition is done at the **select box “Strategy”** which is to be found in the area of **“Work procedures”** sub area **“Distribution of working time”, “Employment of workers”** on the **module parameter mask**. Work station “below” only requests a worker for set-up activities, so this definition is done in the “Set-up time” area of the module parameter mask.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

9.3.1 Work Stations

Please double click on work station “above”.

- Use the **select box** named **“Strategy”**, which is to be found in the area **“Distribution of working time” “Employment of workers”** of the opened parameter mask, to select **“Maximal no. of workers”**. The “Strategy” specifies the relationship between the inscribed working time (processing time) and the number of workers. In case of “Maximal number of workers” this means, that the inscribed “working time” will be spent exactly, if the number of workers available at the work station is equal to the inscribed “Maximal number of workers”. If less worker are available, then the actual working time at the work station prolongs according to the ratio **(Maximal number of workers):(Actual number of workers)**.
- There are four input boxes on the right side of the select box described above. Please enter the value “1” into the first three boxes and press the “TAB” key on your keyboard after each entry. The first and the second box define the minimal and the maximal amount of available workers. In the third box the requested level of qualification is to be assigned. Enter a “0” in the **“Intrp”** box (Interrupt). This means that work at this work station is not allowed to be interrupted. The entry in this field corresponds to the limit of the priority of a task. The activity of workers accomplished at this work station can be interrupted only if another work station needs that worker for a task, whose priority is higher than the “Interrupt” limit. Here lower numerical value corresponds to a higher priority („0“ = highest priority). Example: “Interrupt at Station A = 3” => only tasks with a priority value less or equal “2” (higher priority) may interrupt processing at Station A.
- Now repeat this two steps for work station “below”. Pleas regard that the worker at work station “below” is not requested for object treatment but for set-up activities. This entries are done in the **“Set-up times”** area.

Parameter mask of work station “above”

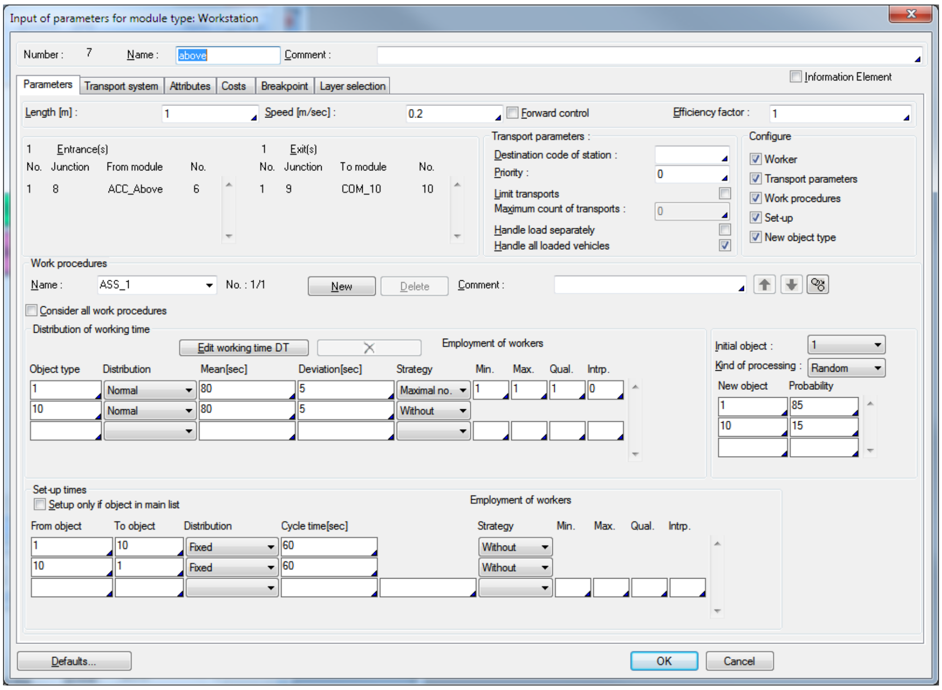


Figure 9.3: Parameter of work station “above”

Set-up parameter of workstation “below”.

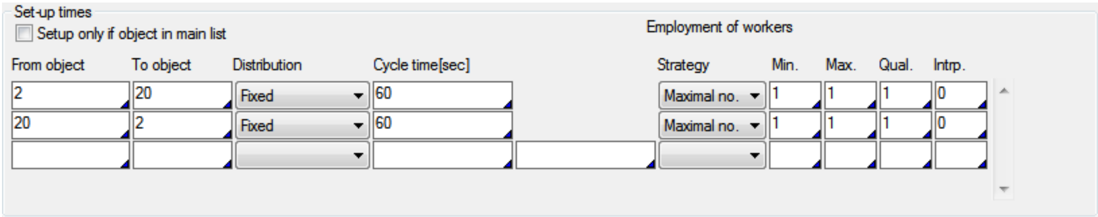


Figure 9.4: Set-up parameter of work station “below”

9.3.2 Work Area

Now the parameter settings at the work area can be done.. Please proceed as follows:

- Open the parameter mask by double click on the symbol of the work area module.
- Define **“List of workers”**: Click on the input box named **“Qualification”** and enter the value of “1” (“1” is the highest qualification level). Then press the **“TAB” key** on your keyboard and enter the **“Quantity”** of “1” (quantity, number or workers).
- **“Worker assignment”** and **“Task assignment”:** Default settings in both arrays can be accepted.
- **“Defined Tasks”:** The first input area contains the number of the task (**“No.”**, enter **“1”**). Then select **“process object”** from the select box named **“Kind”** and **“above”** from the select box **“Element”**. The priority (**“Prio.”**) specifies the preference of that task (here **“2”**). Please enter the following assignments in the second line: **No. = “2”**, **Kind = “set-up”**, **Element = “below”** and **Prio. = “1”**. Thus set-up task at work station “below” has higher priority and will be processed with preference.
- **Change of work place:** It is possible to select a strategy for changing the work station from the select box for each defined task. For the first task, at work station “above”, a delay of 6 seconds is to define. The worker will wait for this delay time for the arrival of a further object at that work station. So select **“when delay > n sec.”** from the **select box** and enter **“6”** in the input box named **“n:”**.

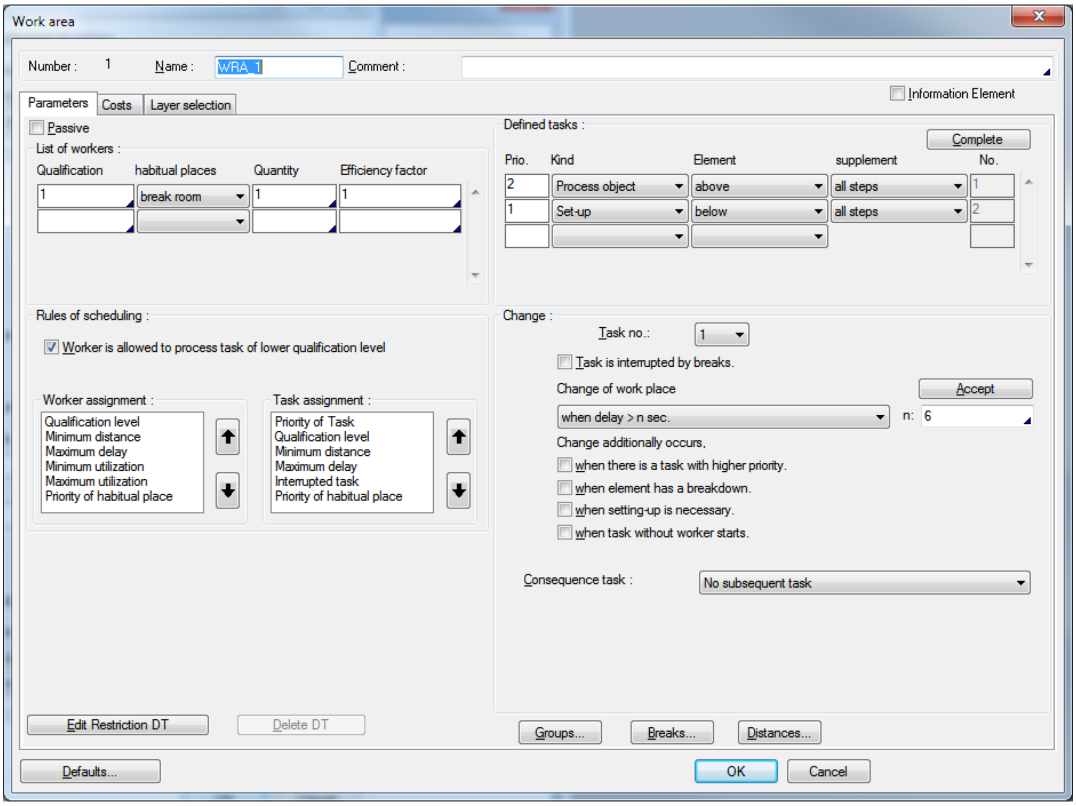


Figure 9.5: Parameter of the work area

- **Breaks:** Click on the button **"Breaks"** of the module parameter mask. Those in the following illustrated parameter mask appears. Click on the button **"New"**. Select the option **"…periodically"** from the select box inside the "Failure" area and enter **"0"** in the field named **"Start of 1st period"**. Enter **"8:00"** in the input box named **"Duration of period"** for a period of 8 hours. Now enter **two pauses according to the figure illustrated below** in the array below. Please regard to enter **"Begin"** and **"Duration"** of each pause during one period. This pauses are to be filtered out of statistic data, too. So please select the **check box "Without statistic"**. Click on the **"OK" button** after all of this is done.

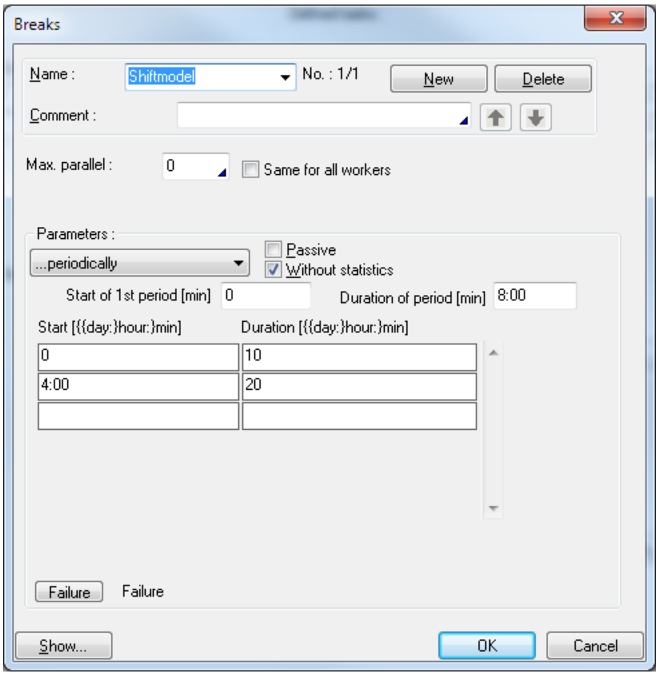


Figure 9.6: Pauses

- **Distances:** Please click on the button named **"Distances"**. The Work Area parameter mask disappears, the model appears again and the parameter mask named **"Path list"** is displayed in the foreground. Modules that are referred by the "Time" to set in the "Path list" are displayed in blue color in the model. If only one module is marked, then the referred path is the way between that module and the Work Area. Make sure that the accordant modules are selected. Please enter all **"Time"** values according to the figure below. When done, click on the **"OK" button**. The Work Area parameter mask will be displayed again.

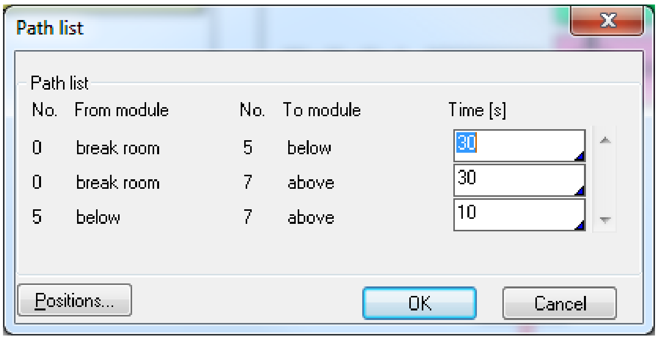


Figure 9.7: Path list

- Finish parameter setting by click on the **"OK" button** or press the **"Enter" key** on your keyboard.

Depending on the object type entering the work station, a worker has to be requested or not. If no worker is available at this point of time, the task is marked as **"undone"** and the module state turns to **"waiting"** (the object is displayed in yellow color). In DOSIMIS-3 there are several module types that support manual tasks: e.g. **"Work Station"**, **"Assembly"** and **"Disassembly"**. This kind of tasks are defined by the generic term "Object Treatment".

Object treatment depends on the type of object, that means that a worker does not have to be available all the time for object treatment at a work station. Additionally worker employment strategies can be defined to control the change of tasks during object treatment.

The activities of workers are displayed in the animation. If this additional animation is not desired, please select **“Simulation“ → “Parameter”** from the menu bar and **deselect** the **check box** named **“Worker trace”**.

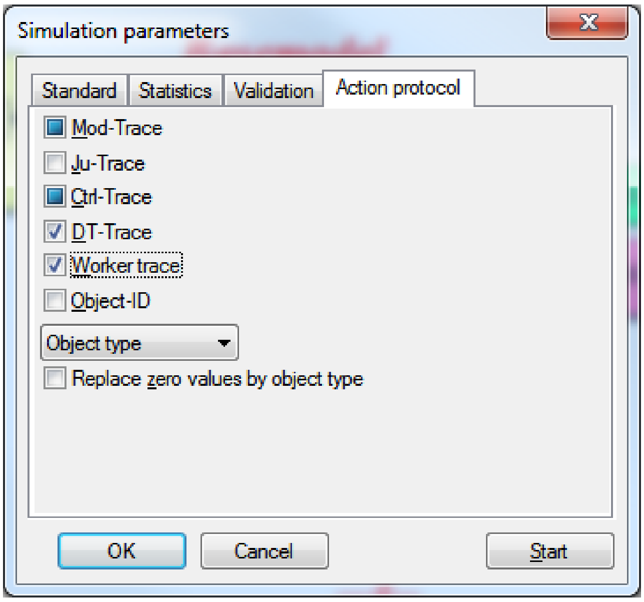


Figure 9.8: Disable of “Worker trace”.

Changing of this simulation parameter only effects on animation. There is no effect on the procedure of worker arrangement.

9.4 Analysis of Work Area

After simulation run has finished you can start animation mode and watch the model. Please select **“Single step”** by click on the appropriate button of the **“animation bar”**. Worker #1 is displayed in red color inside the work area. That means he is at his regular work place and has a break (the worker is paused). The break lasts 10 minutes. The first object enters work station “above” after about 2 minutes of. simulation time. As the object has entered the work station completely its color turns to yellow and displays the state of “waiting for worker”. After 10 minutes of simulation time the worker leaves his work area and moves to work station “above”. Thus the worker position (Working place displayed as cycle) of work station “above” changes its filling color to green. As soon as the worker arrives at the work station and starts to work, the “working place” is displayed in blue color. **Note that contemporaneous events are animated successively.** That is why the object in work station “above” will be displayed in blur color (working) in the next step. However both events take place at the same time, what you can watch at the “digital display” of simulation time. After the object has left work station “above”, its “working place” appears in yellow color. This is because of the fact that the worker still waits maximally 6 seconds for the next object to enter the work station completely.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

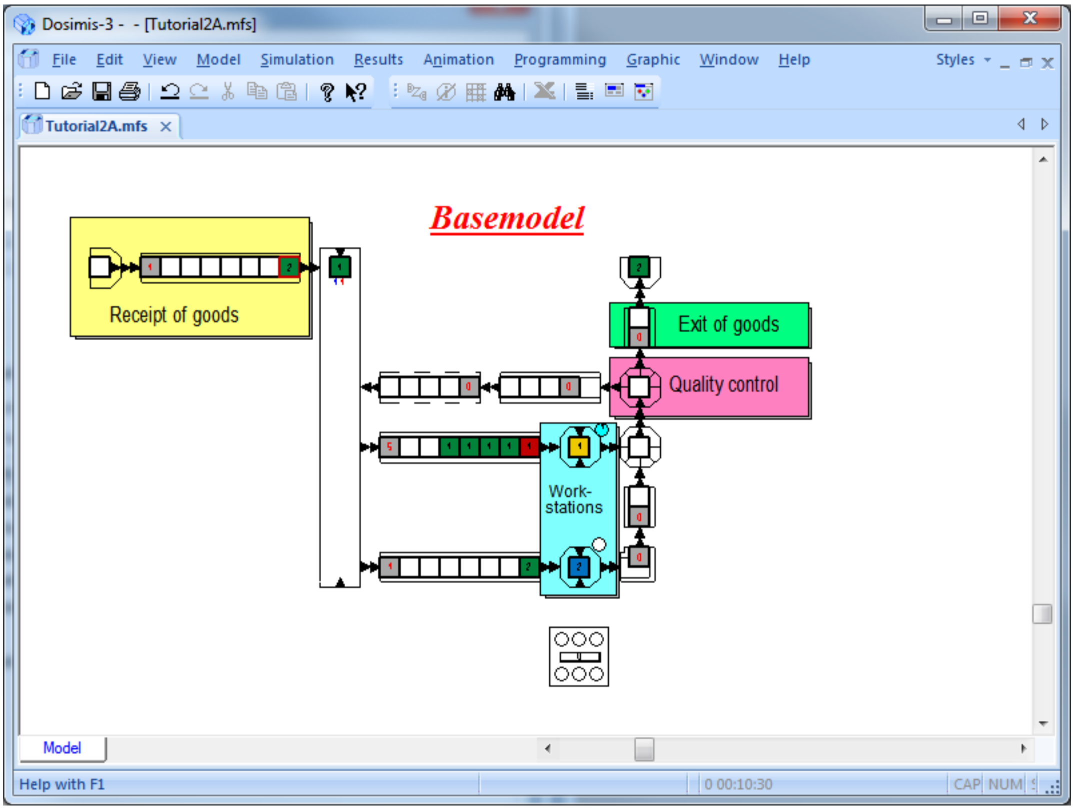


Figure 9.9: Object treatment at work station "above"

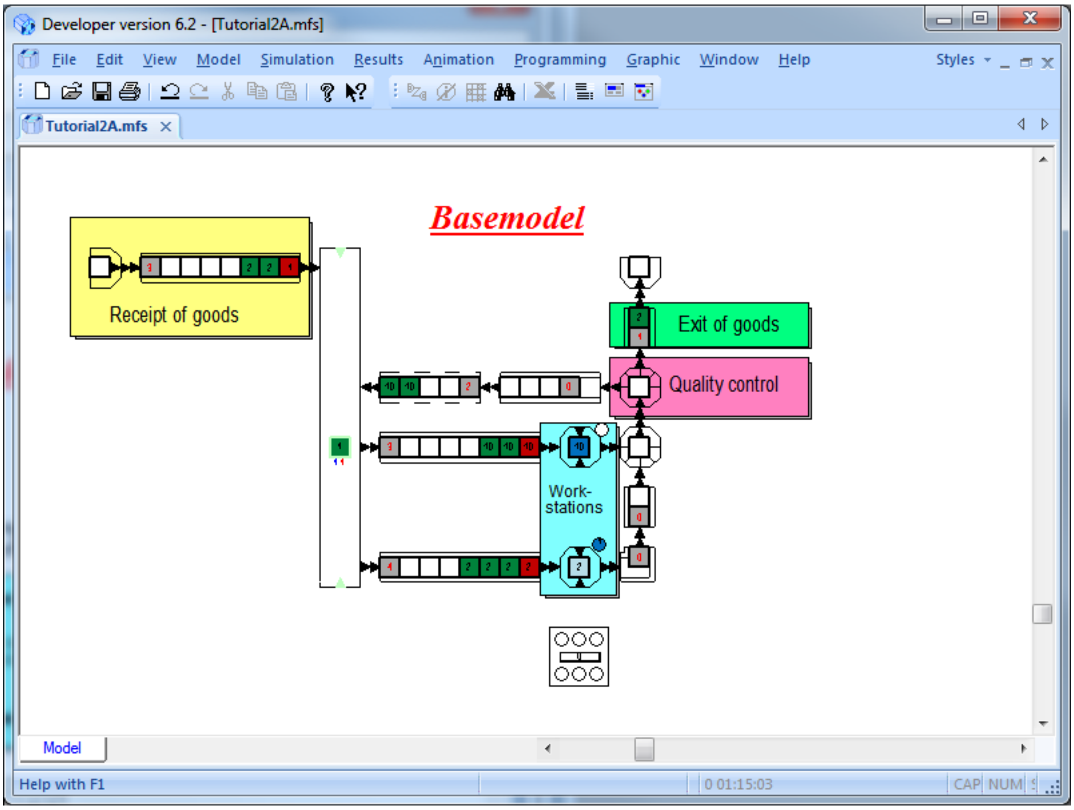


Figure 9.10: Set-up activity at work station "below"

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

The color of an object which is shown as a rectangle displays the status of this object.. Thus applies particularly with worker employment:
Yellow = waiting for worker
Magenta = waiting for Set-up worker

9.5 Statistic

After simulation run has finished it is possible to display the results of the work area in form of bar charts.

- Pleas select the work area by mouse click on its module.
- Then select **"Results"** → **"Result Parameter"** from the menu bar.
- Mark the **check box** named **"Statistic Point in Time"** which is to be found on the **"Selection" tab**. The final statistic at of the point in time of 600 minutes is to be displayed.
- Click on the **"Exit" button** to accept your changes and to close the "Result Parameter" mask.
- Now select **"Results"** → **"Work Area Statistics"** from the menu bar.

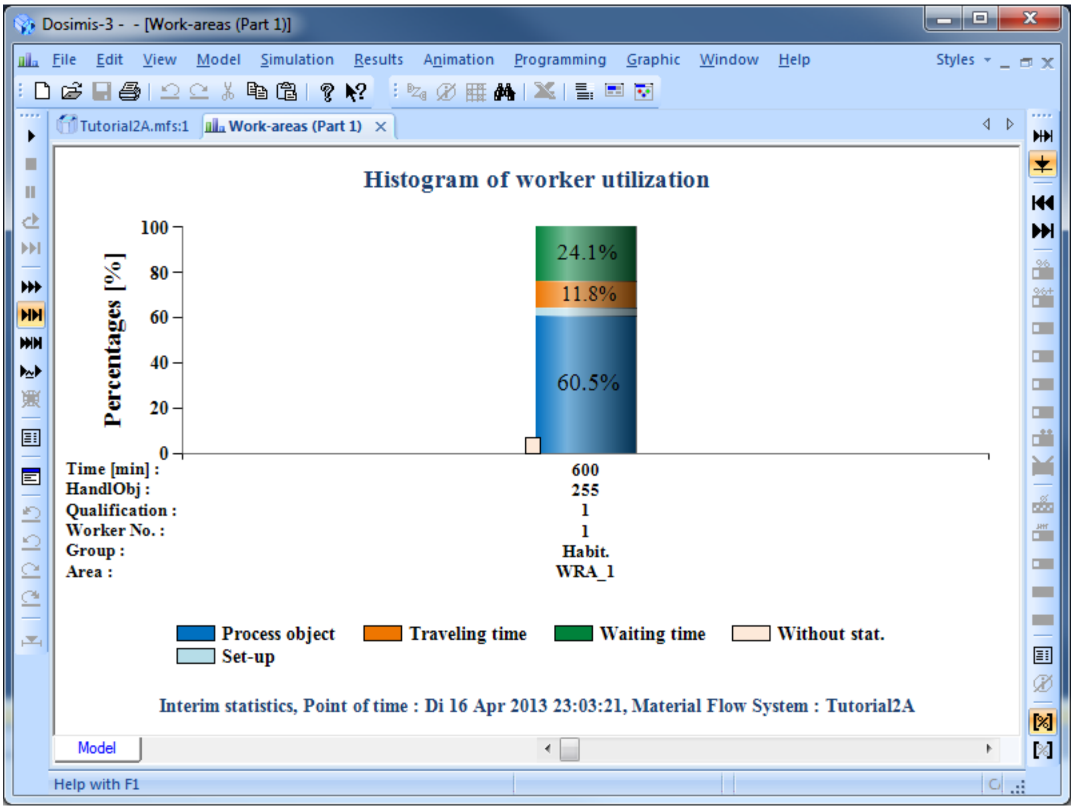


Figure 9.11: Final statistic of work area

In this case worker utilization shows a quite high reserve (Waiting Time). This seems to be sufficient. However a look on the statistics of the work stations leads to another interpretation.

- Please select both work stations for this.
- Then select **"Results"** → **"Time Histogram"** from the menu bar.

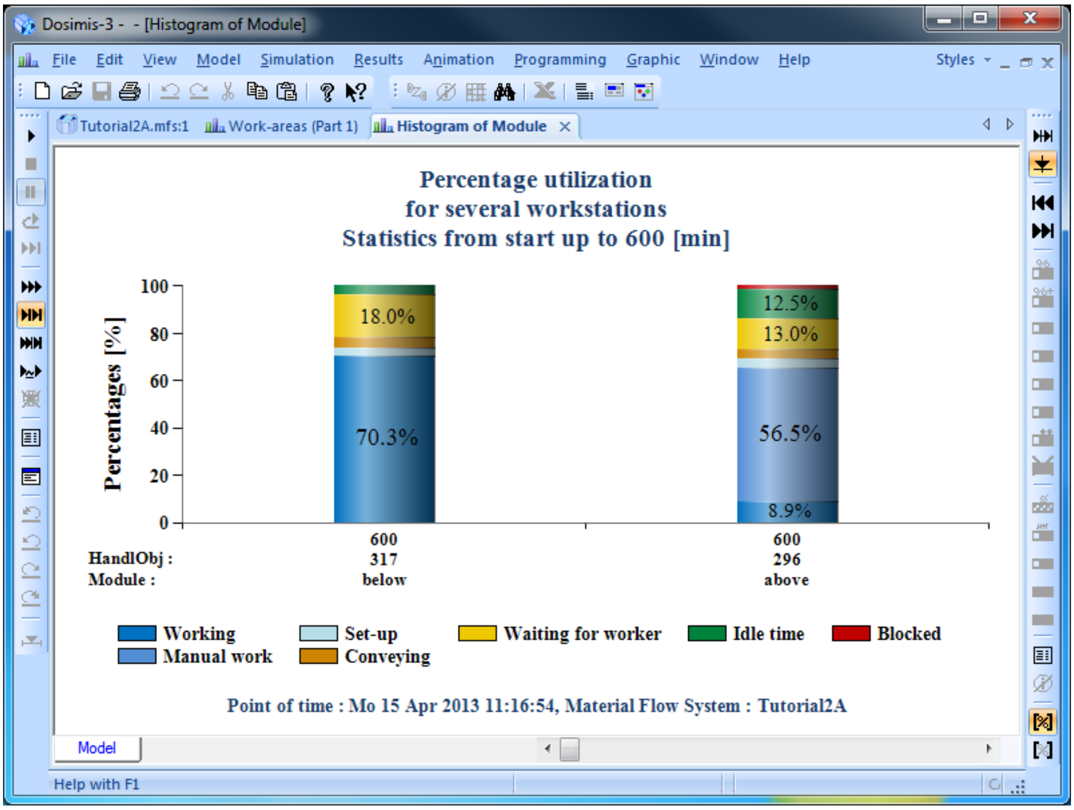


Figure 9.12: Final statistic of both work stations

There are high portions of **"waiting for worker"** on both work stations. This can be verified in the final statistics, too. Similar values appear in the statistics of all other modules. These results show that worker and machines thwart each other by "waiting for each other" and so system performance is to be reduced. Thus throughput at the sink is approx. 16% lower in this simulation run than in a simulation run without worker.

Waiting times of the worker result from:

- the time a worker has to wait until the next object has entered work station "above" (5s travel time, 6s maximal waiting time).
- the inactivity of the worker during rework at work station "above".
- and waiting for objects.

Waiting times of the machines for the worker result from:

- pause times of the worker,
- the occupation of the worker by the other work station in each case and
- in case of work station "below" due to the fact, that the worker will not be released from work station "above" until there is a change of object type (from 1 to 10) or the buffer before is empty.

Please select **"Results"** → **"Statistic Data"** from the menu bar to display the final statistics.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

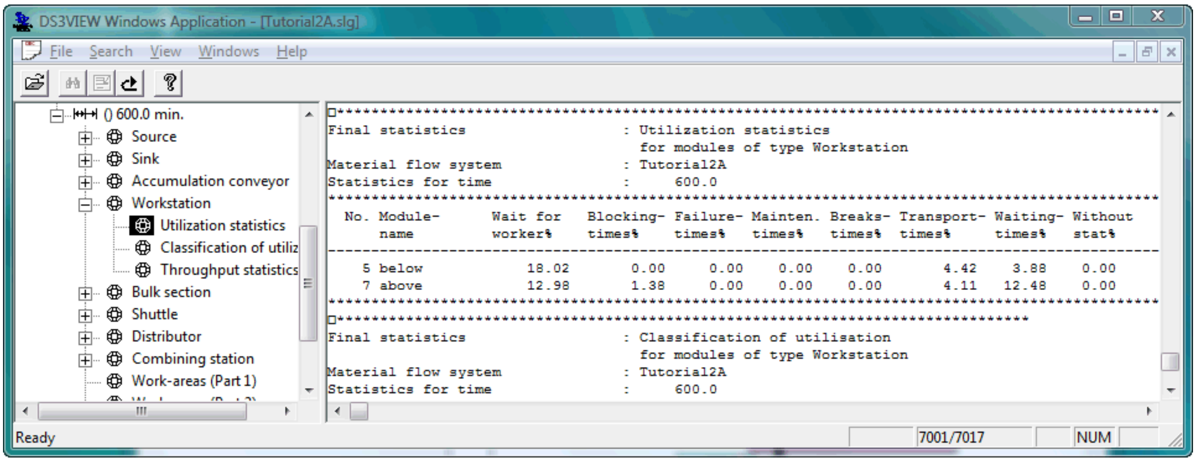


Figure 9.13: Final statistic (utilization of work stations)

The statistics of “work areas” is to be found below statistics of modules.

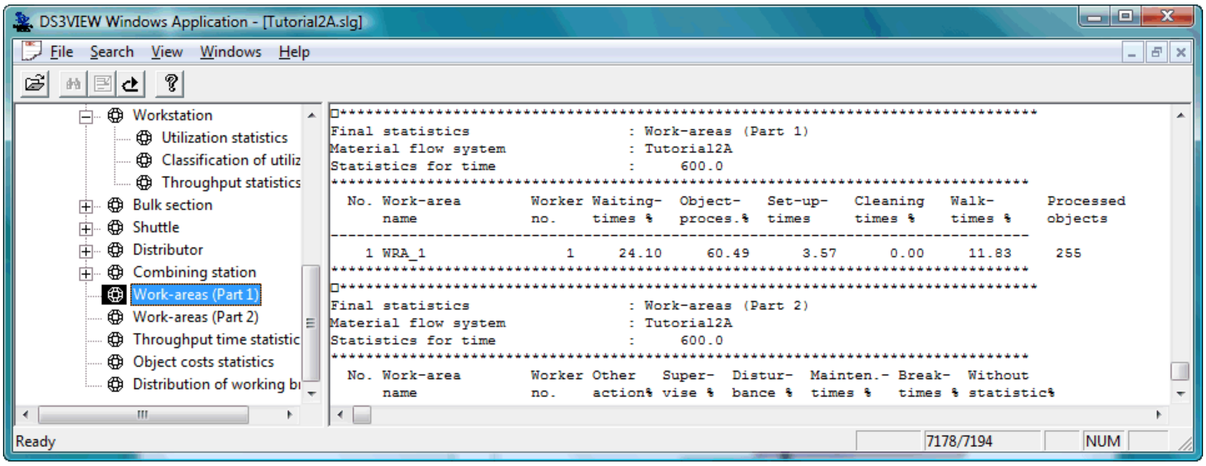


Figure 9.14: Final statistic (work area)

9.6 Several Worker per Task

With extensive activities often it is necessary that several workers have to work at the same time on one task. This is supported by the worker employment strategy of DOSIMIS-3, because it is possible to assign a minimal and maximal number of workers to each task. The work time that is set always refers to the registered maximal number of workers. Work start when the minimal amount of workers are available. If the values of minimal and maximal number of workers are different, then the process time will increase inversely proportional to the number of active workers. So, if the maximal number of workers needed is three and only two workers are available, process time will be prolonged by 50% (“maximal number of workers”/”actually number of workers” * work time = 3/2 * work time).

Now for each object treatment one worker is needed in the example model. For set-up activities however two workers are necessary for each work station.

Manning level necessary for one task can be entered in the input boxes of “Employment of workers” Strategy in the parameter mask of the work stations.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

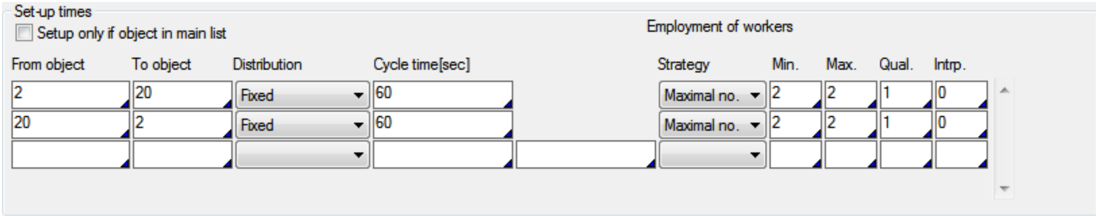


Figure 9.15: Several workers per task

Please extend worker employment strategy of both work stations in such a way, that each object treatment will request one worker and each set-up activity will request two workers. If all workers work according to the same shift model, the number of workers could be increased to two in the existing work area. But if the shift models (pause times) of the two workers are different, a second work area has to be included into the model. After the existing work area has been copied and the "Working places" have been placed, the new model looks like following:

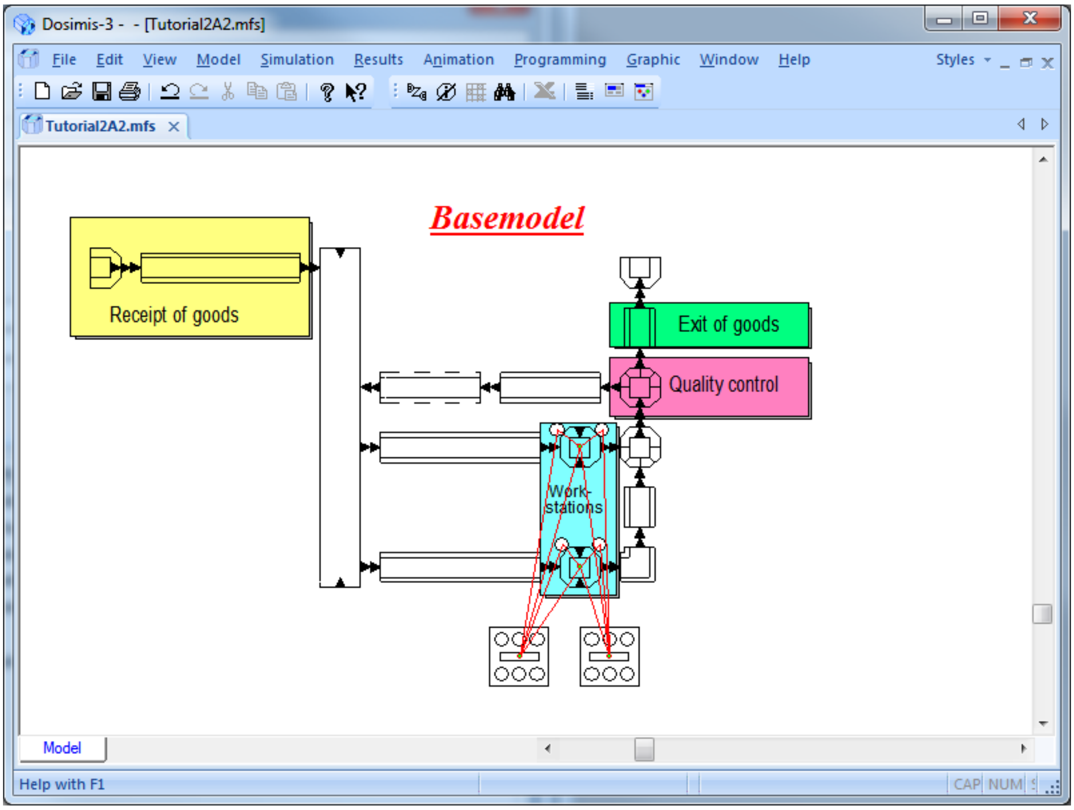


Figure 9.16: Relations of elements in the model

To display the connections between the elements please select **"Model"** → **"Info…"** → **"Connections"** from the menu bar. The two work stations are connected to the two work areas in each case. And one "Working place" at each work station is assigned to one "work area".

Select **"Simulation"** → **"Check Output"** to see the results of "Consistency Check". Some error messages are displayed. E.g. no worker is assigned for object treatment at work station "below". Only if these errors are removed, the model can be simulated.

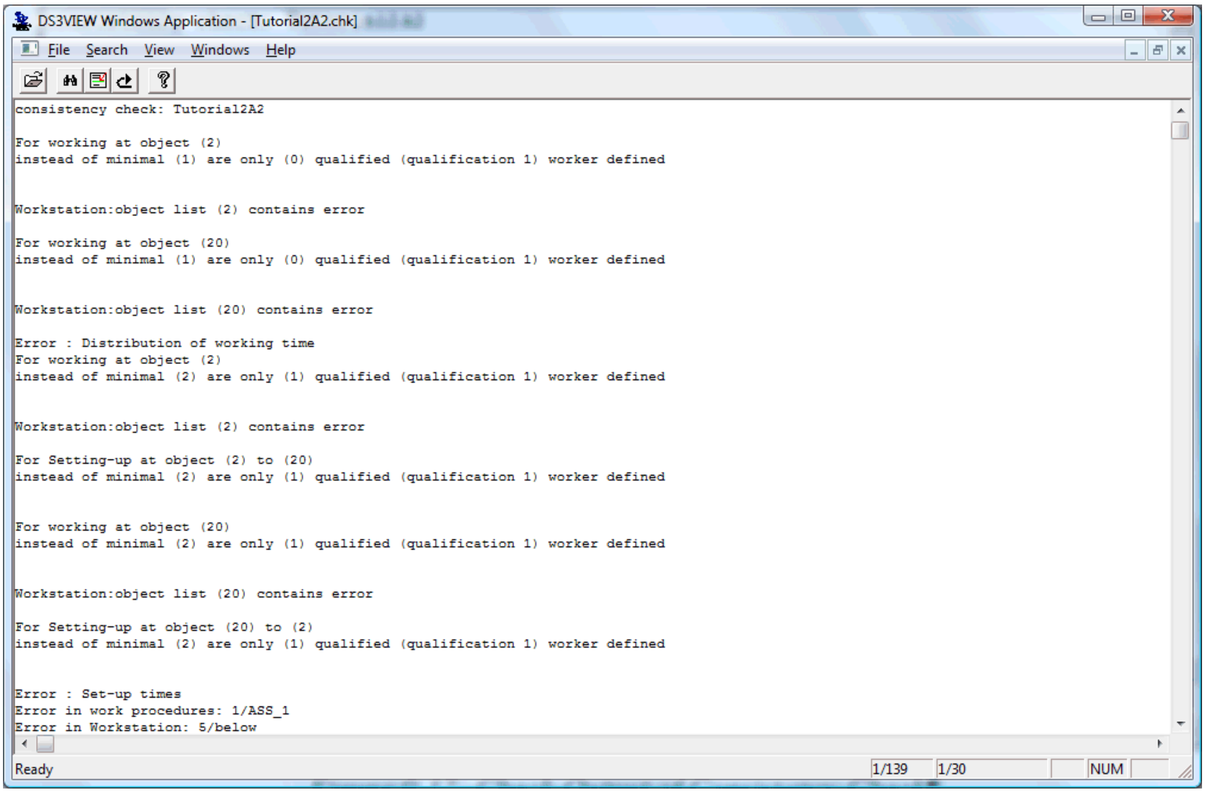


Figure 9.17: Check Output of Consistency Check

For that purpose please proceed as follows:

Supplement in the parameter mask of work area 1 the task:				
No	***Kind***	***Element***	***Supplement***	***Prio***
3	set-up	above	all steps	1
Change and supplement in the parameter mask of work area 2 the tasks:				
No	***Kind***	***Element***	***Supplement***	***Prio***
1	process object	**below**	all steps	2
3	set-up	above	all steps	1

Thus each worker accomplishes the treatment of objects at his work station, if however set-up activities are requested, both workers will cooperate for this purpose. This is because of the fact that all workers are disposed internally independently from an affiliation to a “work area”. The criterion is that a worker **may** work on the demanded activity.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

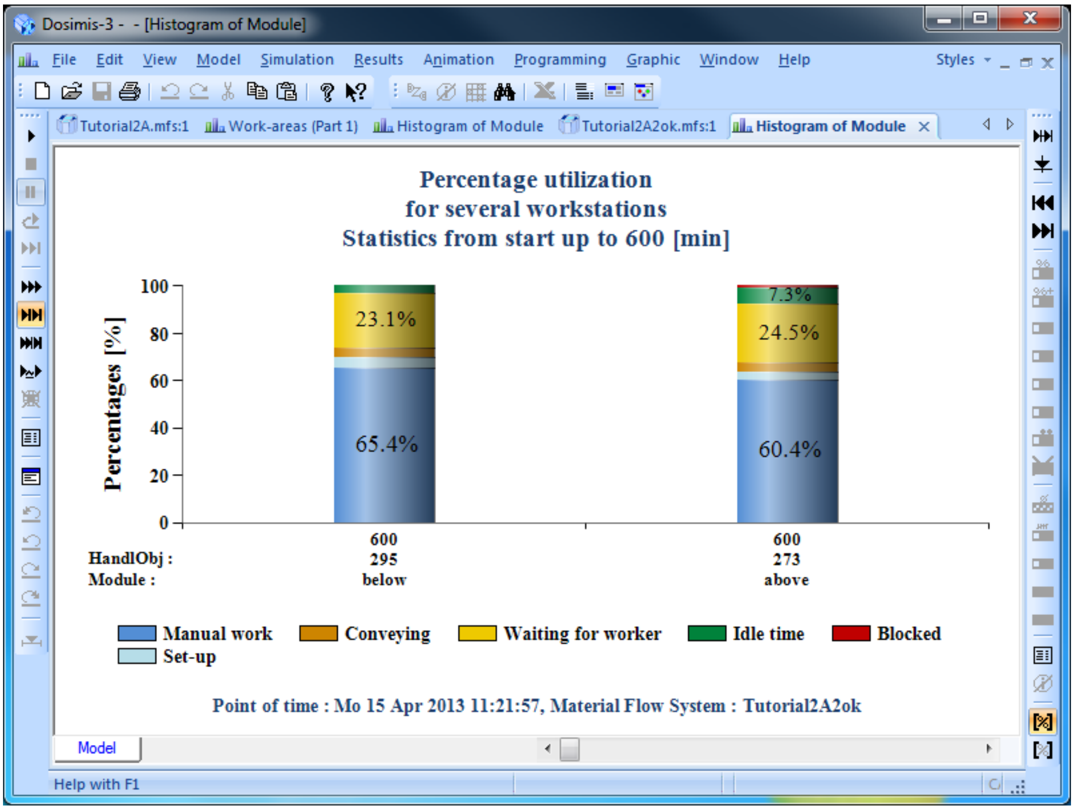


Figure 9.18: Final statistics of both work areas

The “Time Histogram” of both work stations shows a large portion of **“waiting for worker”**. An analysis shows that the work stations wait for workers quite frequently for set-up activities, since workers terminate their treatment of objects first, before a change of working place is possible.

9.7 Interrupt of Tasks

Set-up activities have already highest priority. Since however always two workers are needed, it is always necessary to wait for the worker from the in each case other work station. Now, in case of a set-up request from the other work station, the worker shall interrupt object treatment at his work station and shall change to the other station at once. For this purpose the value of 10 is to be set into the **“Interrupt (Intrp)”** field of the work station parameter masks as shown in the figure below. This means that tasks with a priority higher than 10 (priority 9 is higher than priority 10) may interrupt this task. This parameter change is to be done for both work stations.

Note: The remained work time of the interrupted work is provided again for disposition purposes. However the released worker will not serve it, since a task with higher priority exists. Because only such tasks lead to an interruption.

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

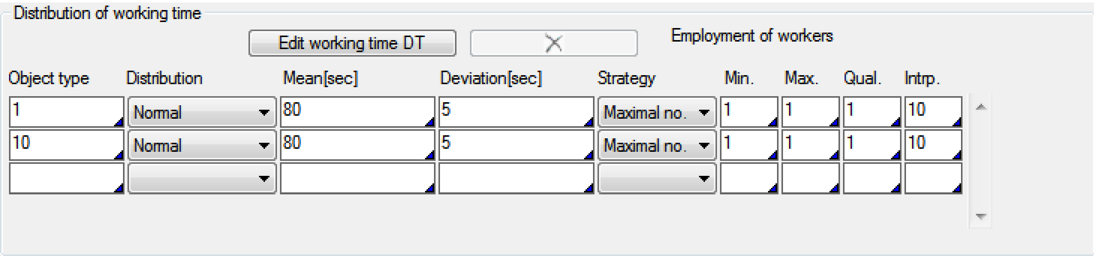


Figure 9.19: Interrupt of task

A look at the result diagram (Time Histogram) shows the desired effect. The quota of "waiting for worker" could be reduced significantly. A further reduction is no longer possible due to pause times of the workers.

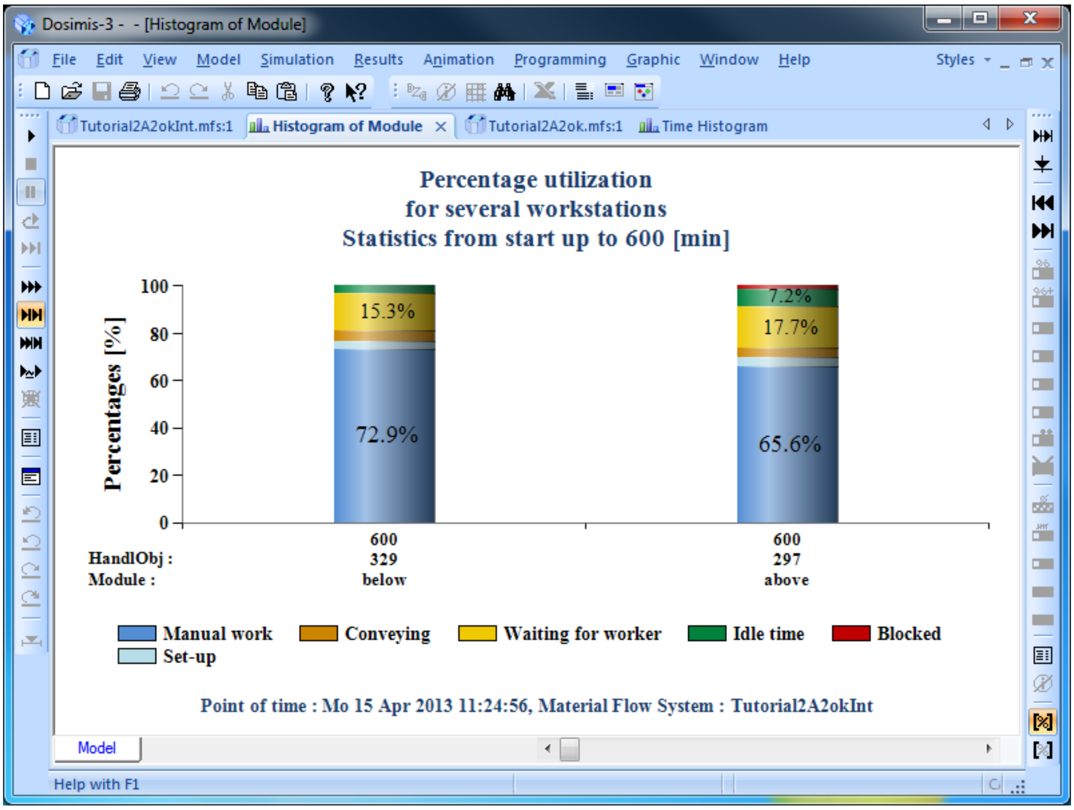


Figure 9.20: Final statistics of work stations

9.8 Passivate Work Areas

Scenario: What, if there were enough workers for each activity always, that means, if there were no “waiting for worker” times? All manual activities are accomplished automatically in this case, so, as if the maximum number of workers is available, the pauses of workers do not overlap and no distance times accrue.

Passivate global

- Please select **“Simulation“ → “Parameter”** from the menu bar.
- Select the check box named **“Disable work areas”.**

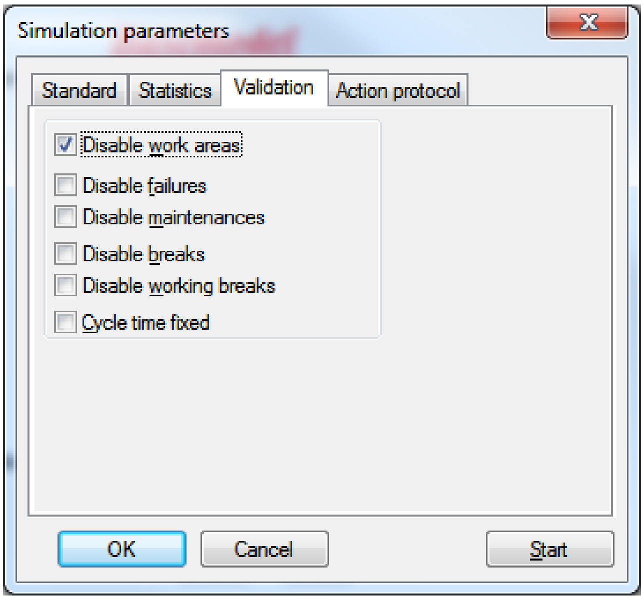


Figure 9.21: Passivate all work areas global

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

10 Index

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50

SimulationsDienstleistungsZentrum GmbH, Hauert 20, 44227 Dortmund
Tel.: 02 31 / 97 50 50 - 0, Fax: 02 31 / 97 50 50 - 50