ŠKODA AUTO University

Computer Simulation of Logistics Processes

Standard Objects of Plant Simulation

Jan Fábry

21/03/2023

Standard Objects of Plant Simulation

ŠKODA AUTO University

Aim of the lecture

- To introduce objects usage and functionalities of the following groups:
  - Material Flow,
  - Resources,
  - Information Flow.

Standard Objects of Plant Simulation

ŠKODA AUTO University

Structure of the lecture

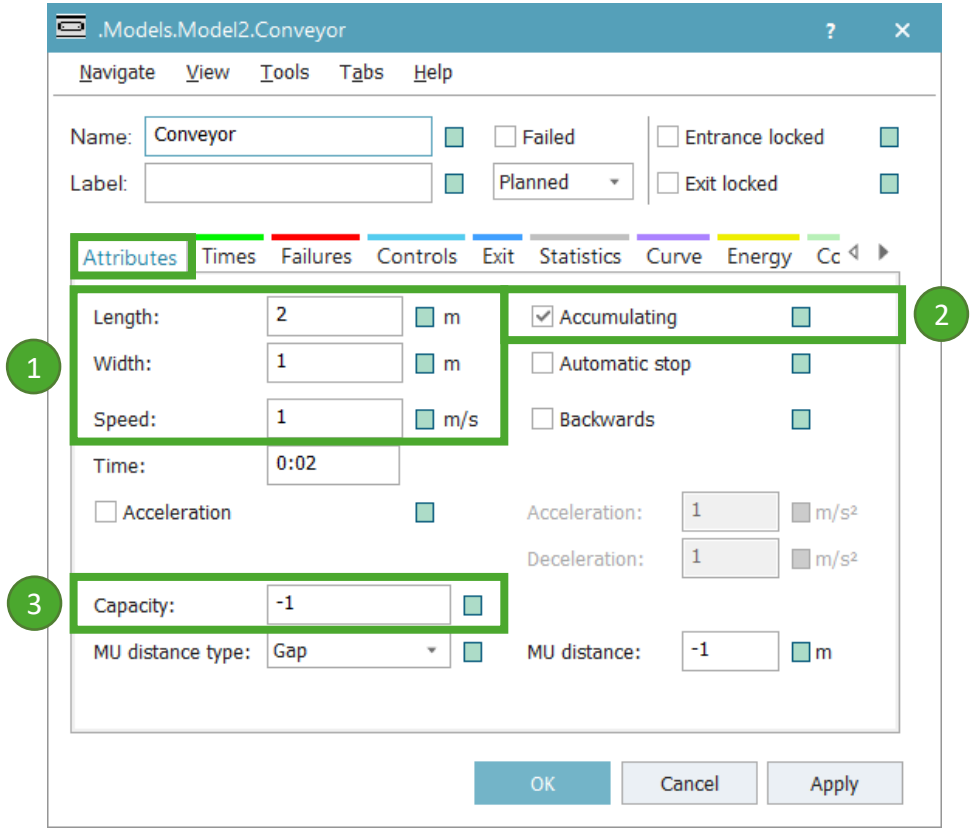
- Standard objects of group “Material Flow”
  - Conveyor, AngularConverter, Converter.
  - Turntable, Turnplate.
  - Track, TwoLineTrack.
  - FlowControl.
  - Cycle.
- Standard objects of group “Resources”
  - Workplace, FootPath, WorkerPool, Worker, Exporter, Broker.
  - ShiftCalendar.
  - LockoutZone.
- Standard objects of group “Information Flow”
  - Method, Variable.
  - DataTable.

Standard Objects of Plant Simulation

ŠKODA AUTO University

Conveyor

- Icon 
- Conveyor can transport MUs.
- Capacity – user-defined (3).
- Length-oriented object.
- The transport time is given by conveyor's length size and speed (1).
- In addition, acceleration or deceleration can be set.
- Selection of "Accumulating" (2) allows MUs to be closely behind each otherin case of a blockade.
- Capacity -1 is default, the capacity is determined by length of conveyor and by the length of transported MUs. The capacity can be limited by specified amount of MUs.

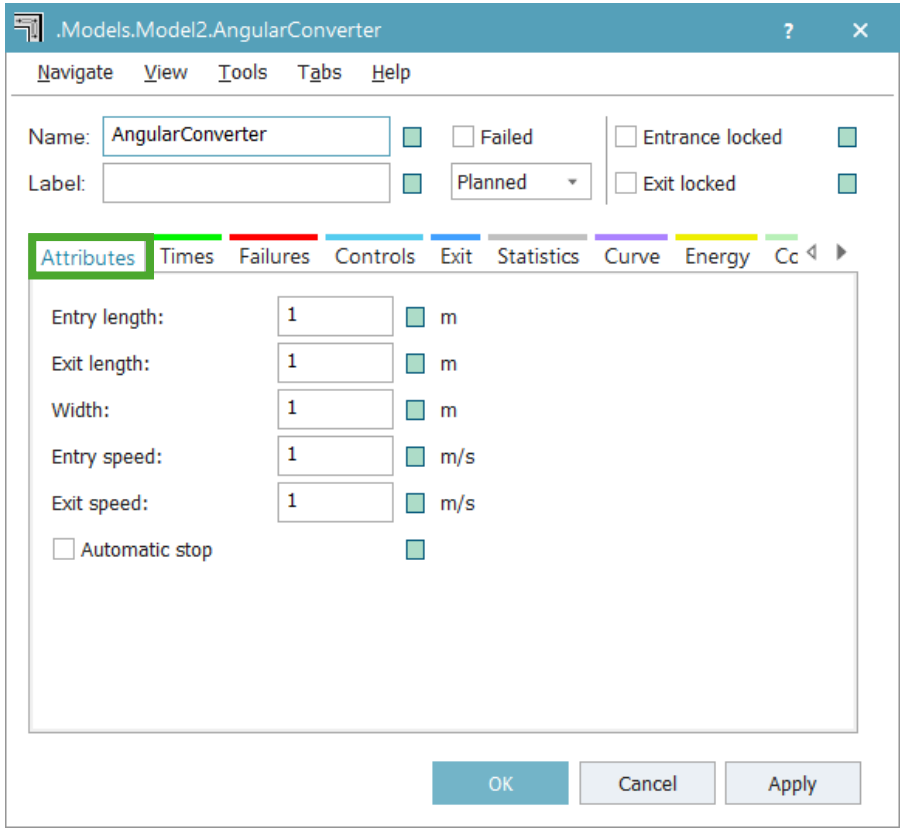


Standard Objects of Plant Simulation

ŠKODA AUTO University

AngularConverter

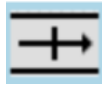
- Icon 
- Capacity – 1.
- The object represents the corner station, where the change from longitudinal to lateral movement is taking place.
- In object “Attributes” there can be defined:
  - Conveyor’s length to the turning point.
  - Conveyor’s length from the turning point.
  - Conveyor’s speed to the turning point.
  - Conveyor’s speed from the turning point.
- Conveyor’s length of the object must be >= length of MUs!

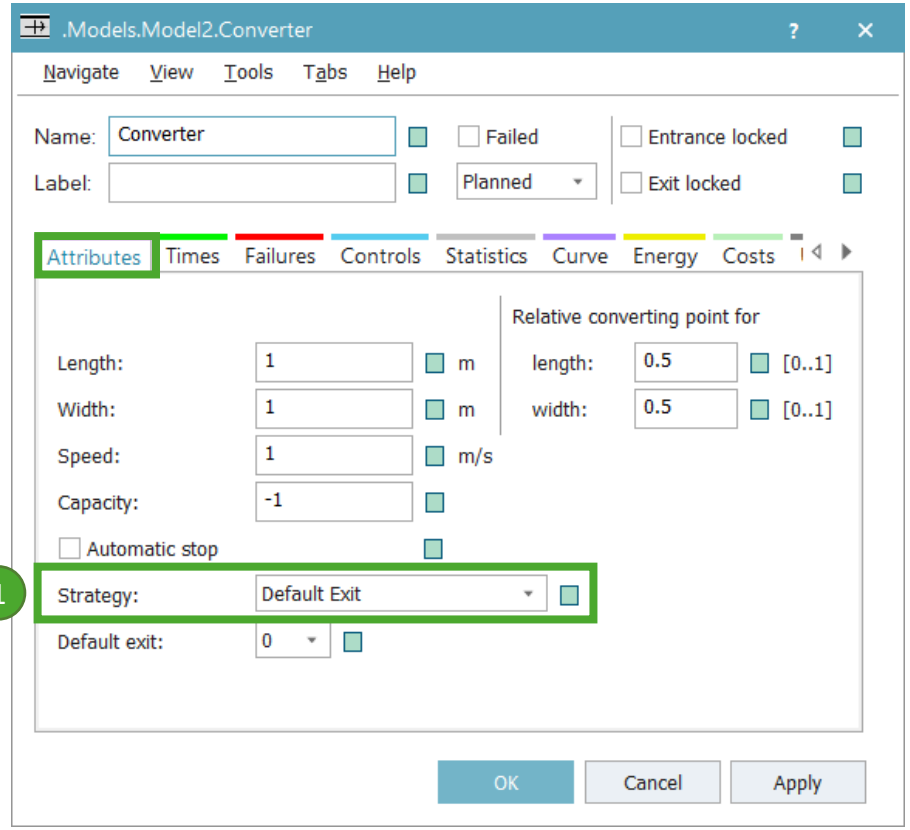


Standard Objects of Plant Simulation

ŠKODA AUTO University

Converter

- Icon 
- Capacity – 1.
- Represent handling table. Part, which comes on conveyor, continues:
  - to the left,
  - to the right,
  - in straight direction.
- Strategy (1) can be set as:
  - “Straight“ – MU is going straight.
  - “MU Attribute“– direction is based on the MU attributes.
  - “MU Name“– direction is based on MU names.
  - “Method“ – own strategy definition based on a method (SimTalk).

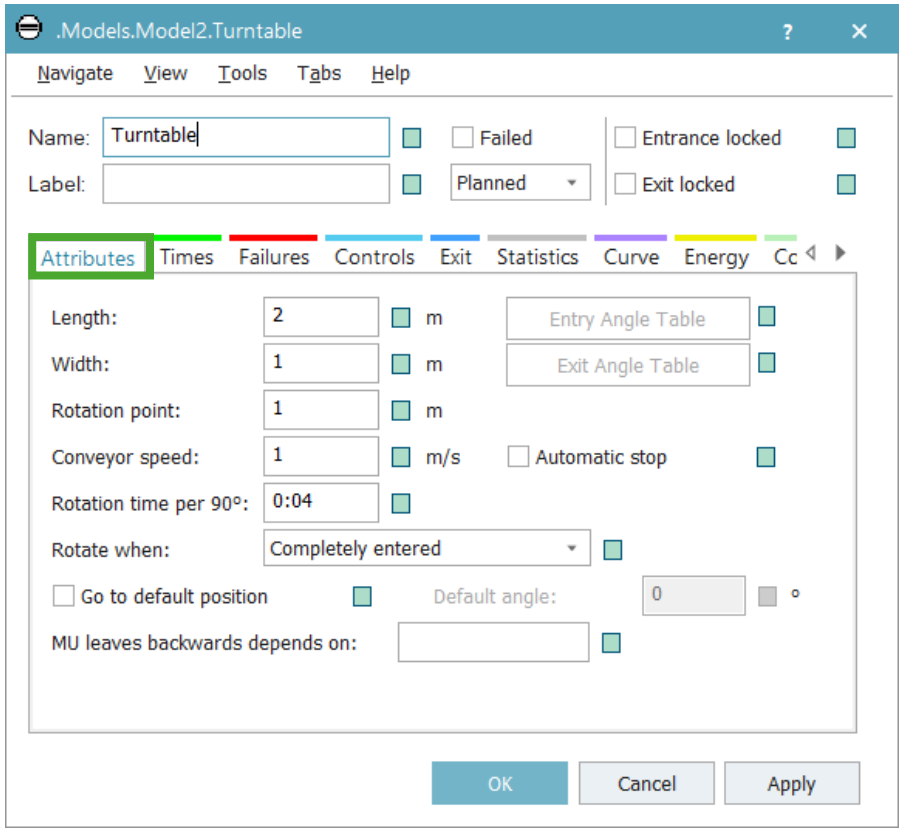


Standard Objects of Plant Simulation

ŠKODA AUTO University

Turntable

- Icon 
- Capacity – 1.
- Turntable represents an object, which distributes MU into other connected objects of material flow.
- The exact direction, where loading on and unloading from the turntable is going, can be defined.
- The rotation of the turntable is in both directions.

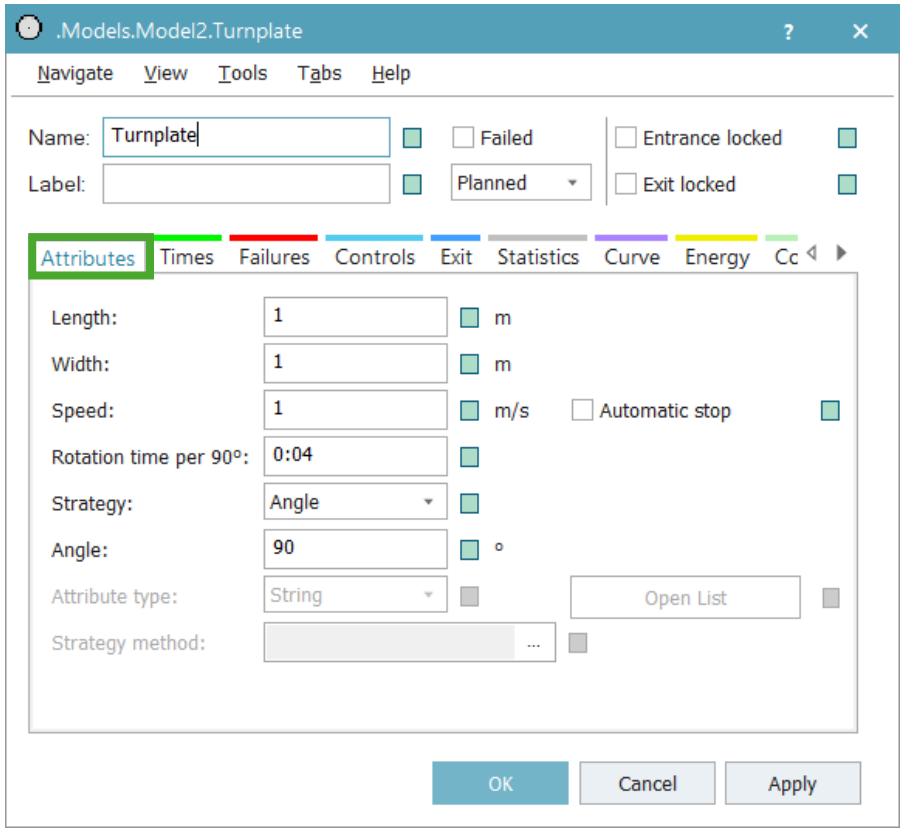


Standard Objects of Plant Simulation

ŠKODA AUTO University

Turnplate

- Icon 
- Capacity – 1.
- Turnplate represents an object, which rotates regularly.
- It is not possible to define a direction of loading on and unloading from the turnplate. It rotates only in predefined angles. This device is typical for logistics companies. They use this principal to scan barcodes for goods identification.
- Only one direction of rotation is possible.

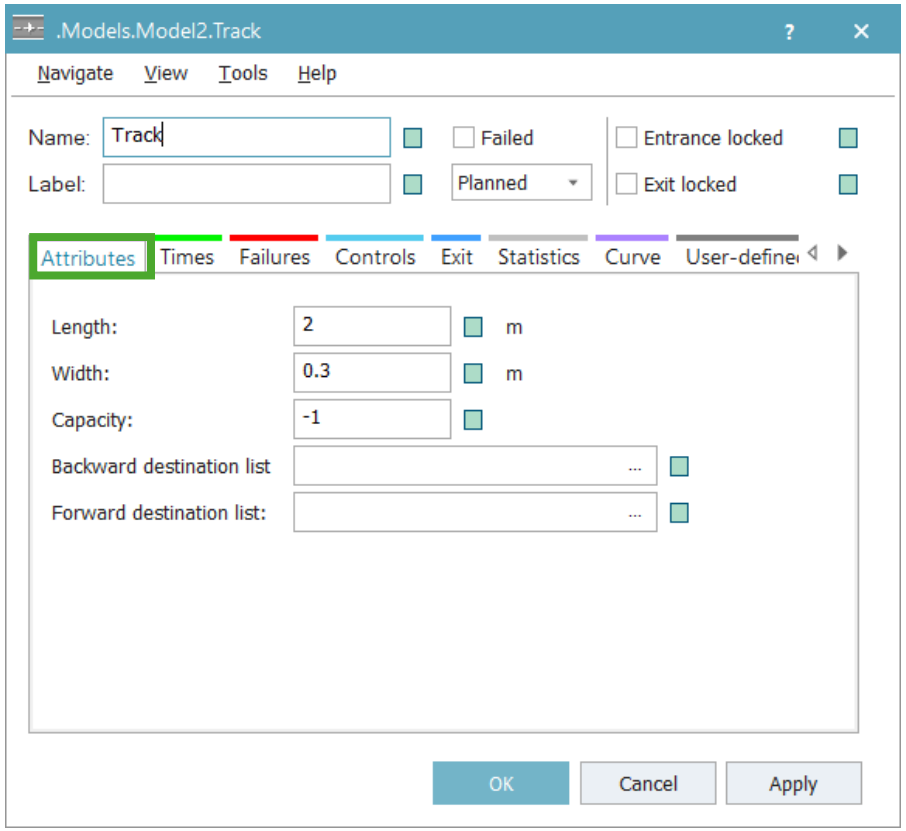


Standard Objects of Plant Simulation

ŠKODA AUTO University

Track

- Icon 
- Capacity – user-defined.
- Length-oriented object.
- It is one way communication, which is used for movement of "Transporter" type.
- Its typical usage is in automatic supply systems for assembly lines and warehouses, i.e. AGV (Automated Guide Vehicle) or FTS carts (Fahrerlose Transportsysteme).
- The distance, which an object must travel is given by track's length, transporter's (MU's) length and transporter's speed.

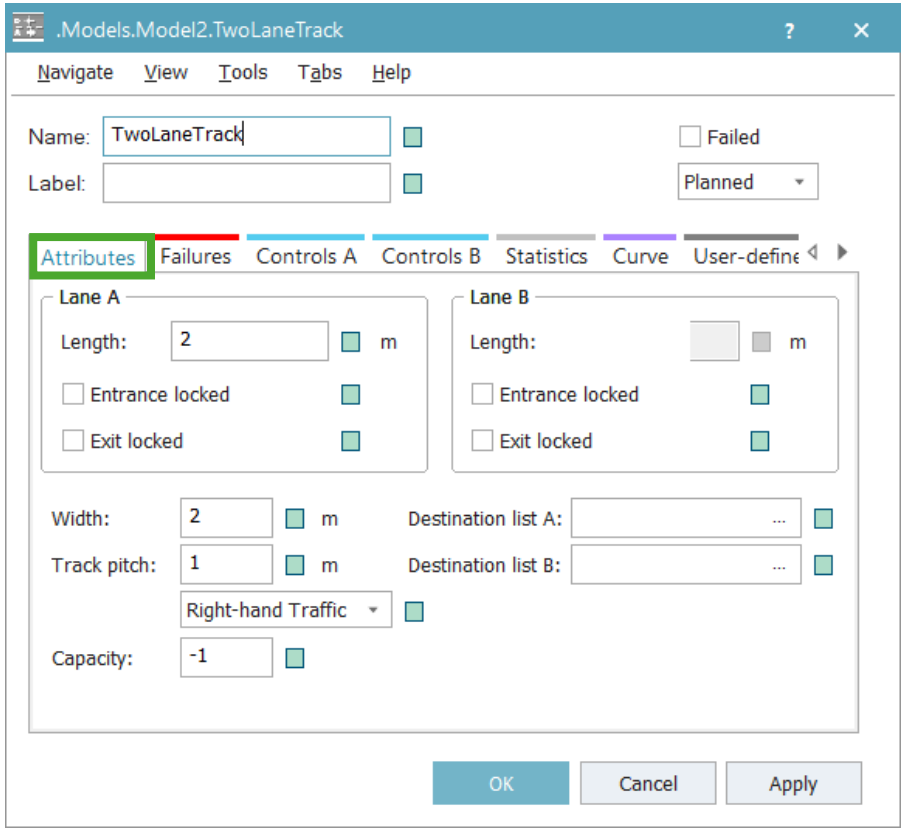


Standard Objects of Plant Simulation

ŠKODA AUTO University

TwoLineTrack

- Icon 
- Capacity – user-defined.
- Length-oriented object.
- From the functional point of view, the object is identical to the “Track” with the difference that we can ensure two-way traffic here.

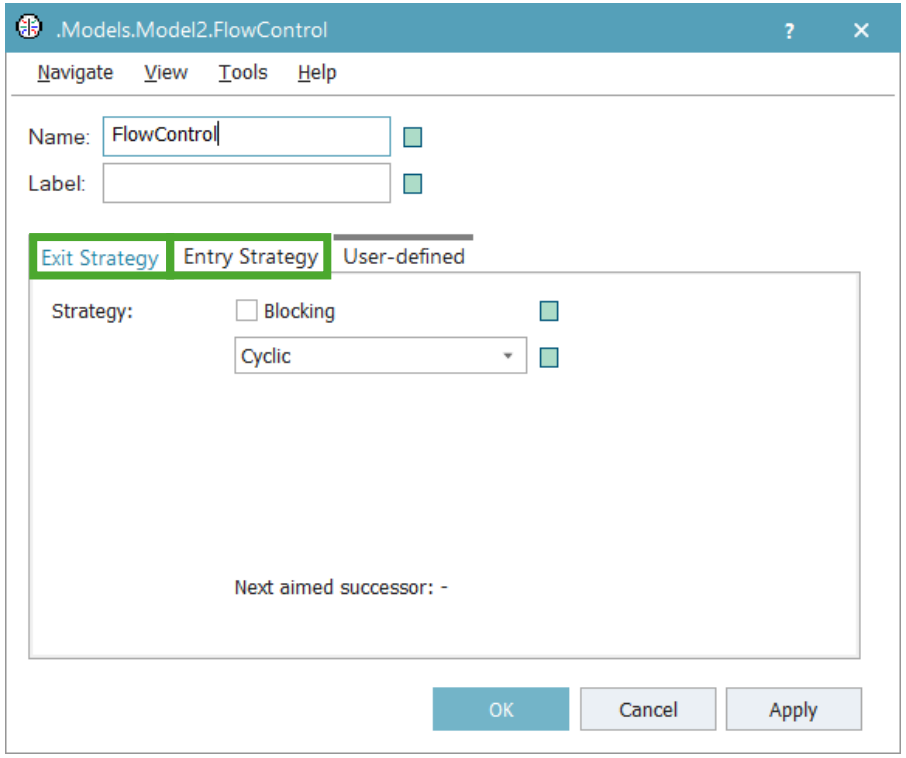


Standard Objects of Plant Simulation

ŠKODA AUTO University

FlowControl

- Icon 
- Zero capacity.
- It controls behavior on entries and exits in the branching and merging points of the material flow.
- It has several predefined strategies for entry and exit – tabs “Exit Strategy“ and “Entry Strategy“:

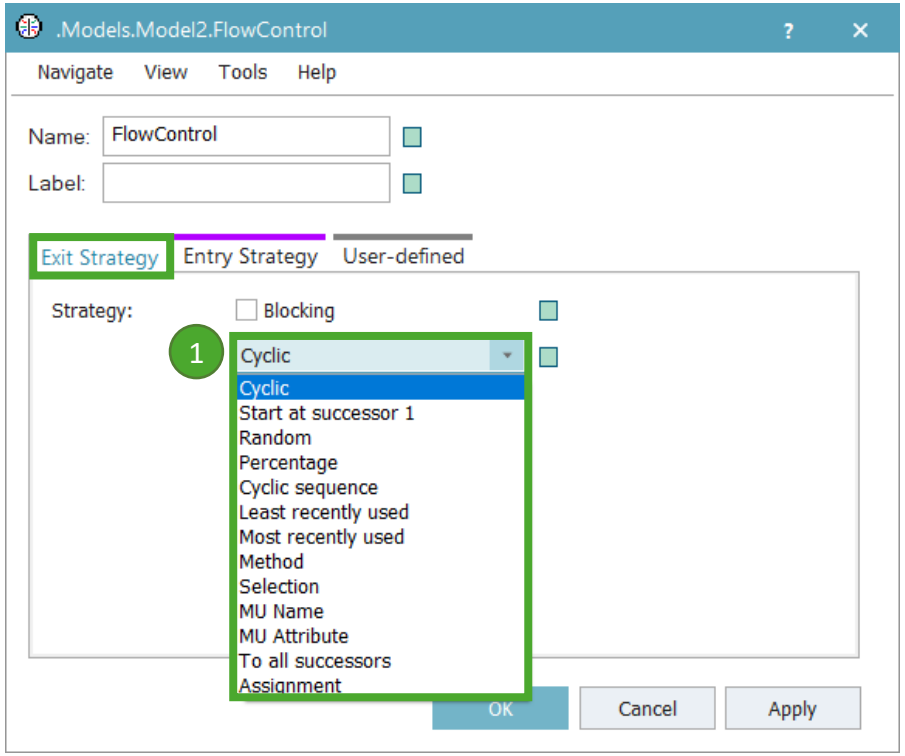


Standard Objects of Plant Simulation

ŠKODA AUTO University

FlowControl (Exit Strategy)

- Icon 
- Strategies for entry/exit (1) – tabs “Exit Strategy“/“Entry Strategy“:
  - “Cyclic“ – in the order, “one by one”.
  - “Start at successor 1“ – the transfer attempt always starts at successor 1.
  - “Random“ – randomly.
  - “Percentage“ – the selection is random, but in a specified percentage rate.
  - “Cyclic sequence“ – the selection is based on the given order of predecessors, which is constantly repeated.
  - “Least recently used“ – MU is passed to the successor waiting for the longest time.
  - “Most recently used“ – MU is passed to the successor waiting for the longest time.

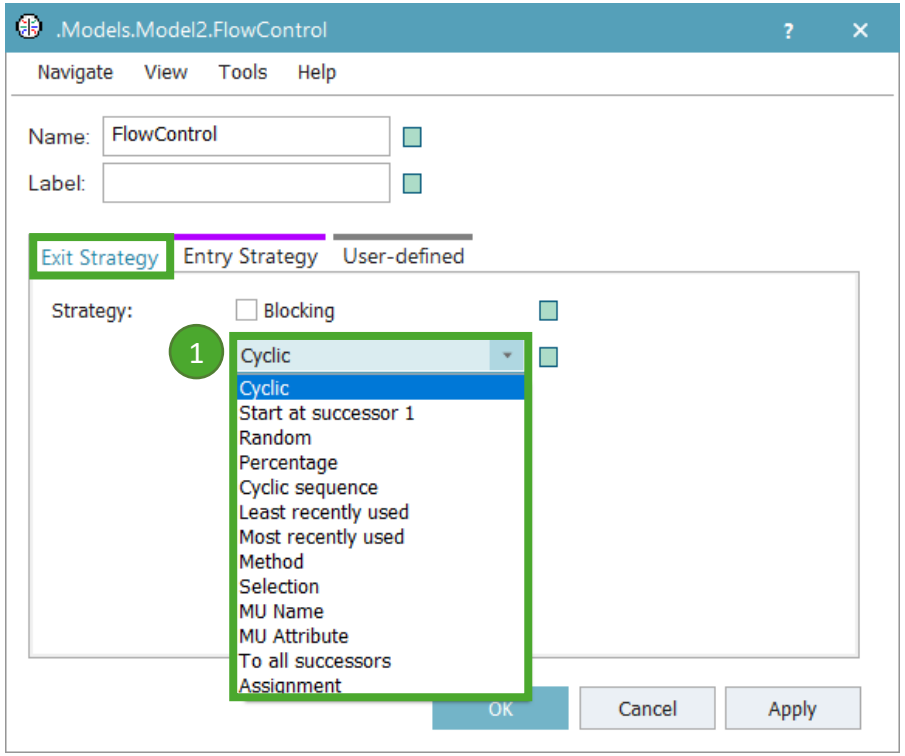


Standard Objects of Plant Simulation

ŠKODA AUTO University

FlowControl (Exit Strategy)

- Icon 
- Strategies for entry/exit (1) – tabs “Exit Strategy“/“Entry Strategy“:
  - “Method“ – the successor is determined by a method.
  - “Selection“ – e.g., based on min./max. content, min./max. amount of entered MUs, the shortest/the longest processing time etc.
  - “MU Name“ – assigned based on MU’s name.
  - “MU Attribute“ – assigned based on MU’s attribute.
  - “ To all successors“ – creates a copy of MU and passes it on each of successors.
  - “ Assignment“– successor is not defined, but the MU’s attributes are changing, when it is passed on (usually to a single successor).

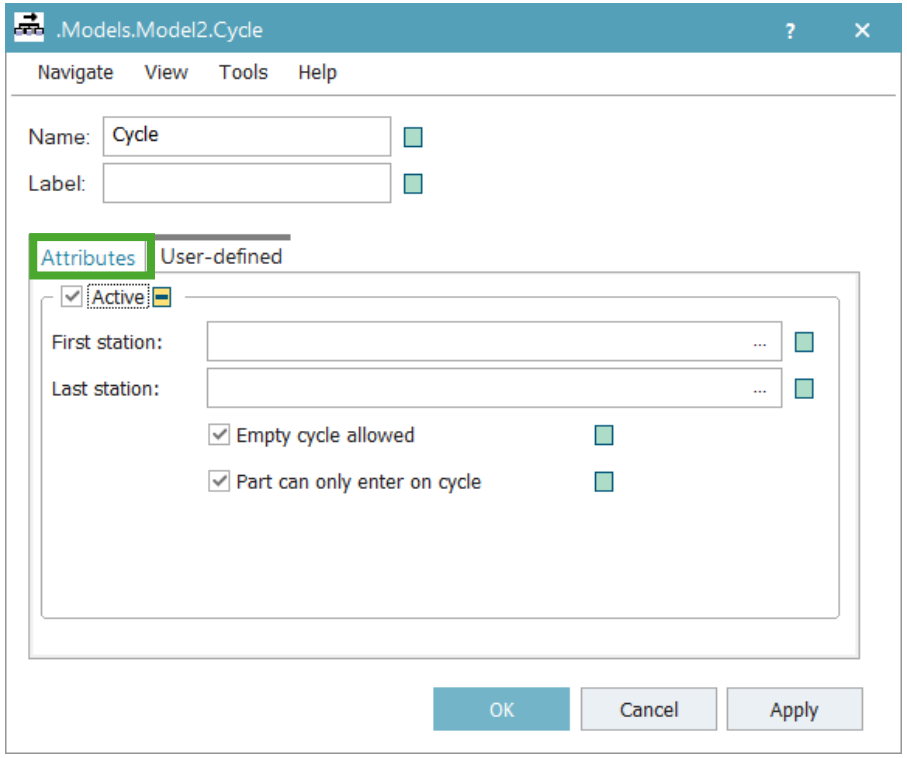


Standard Objects of Plant Simulation

ŠKODA AUTO University

Cycle

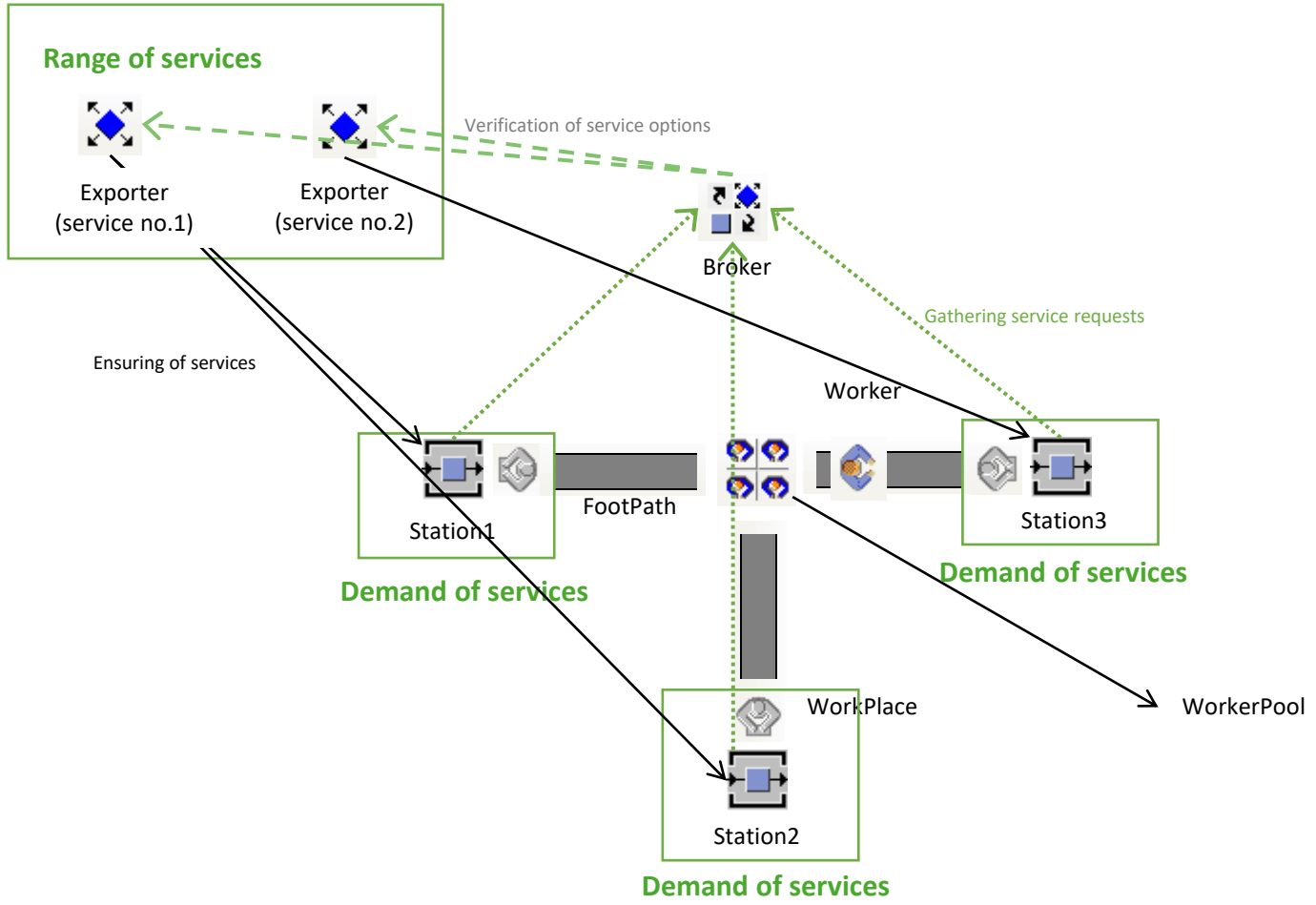
- Icon 
- Capacity is defined by the number of involved objects.
- Object is used for synchronization of MUs' movement between stations in the line.
- The line bounded by this object is defined between entry station "First station" and exit station "Last station".
- Parts can move inside of line only when:
  - All stations finished the processing.
  - None of stations are in a failure.
  - None of stations are in a pause.
  - None of stations are out of the work schedule plan.
- Object "Cycle" can be composed of objects "Station" and "AssemblyStation".



Standard Objects of Plant Simulation

ŠKODA AUTO University

Modeling of worker's labor

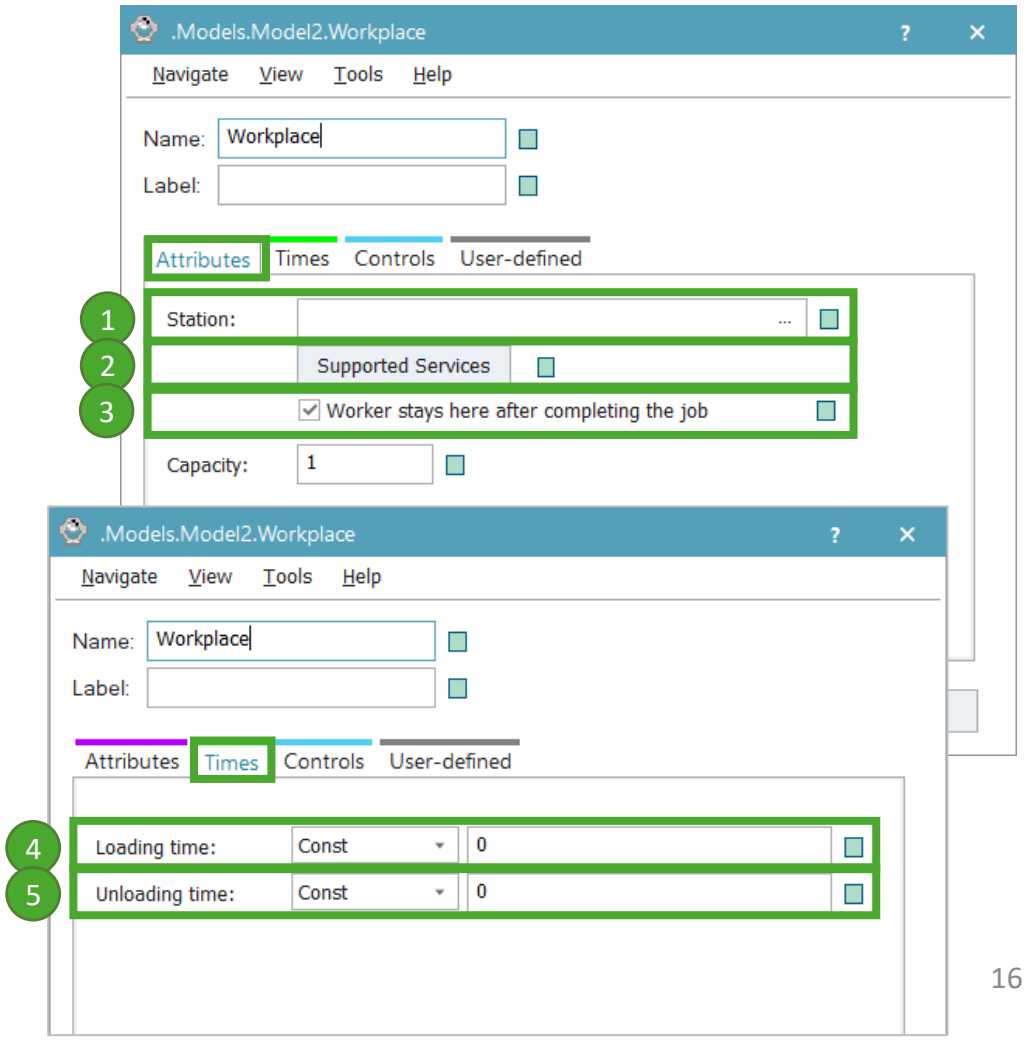


Standard Objects of Plant Simulation

ŠKODA AUTO University

Workplace

- Icon 
- Object of the group “Resources”.
- The object defines the worker’s workspace and assigns it to the material flow objects (1) (Station, ParallelStation, …).
- List below the option (2) “Supported Services” defines types of services, which will be ensured by the workplace.
- The option (3) ensures that worker will stay on the particular workplace after finishing his/her activities (will not return to the “Workerpool”).
- Options “Loading time” (4) and “Unloading time” (5) define the necessary time that worker needs to pick-up the part from the workplace or to place it.

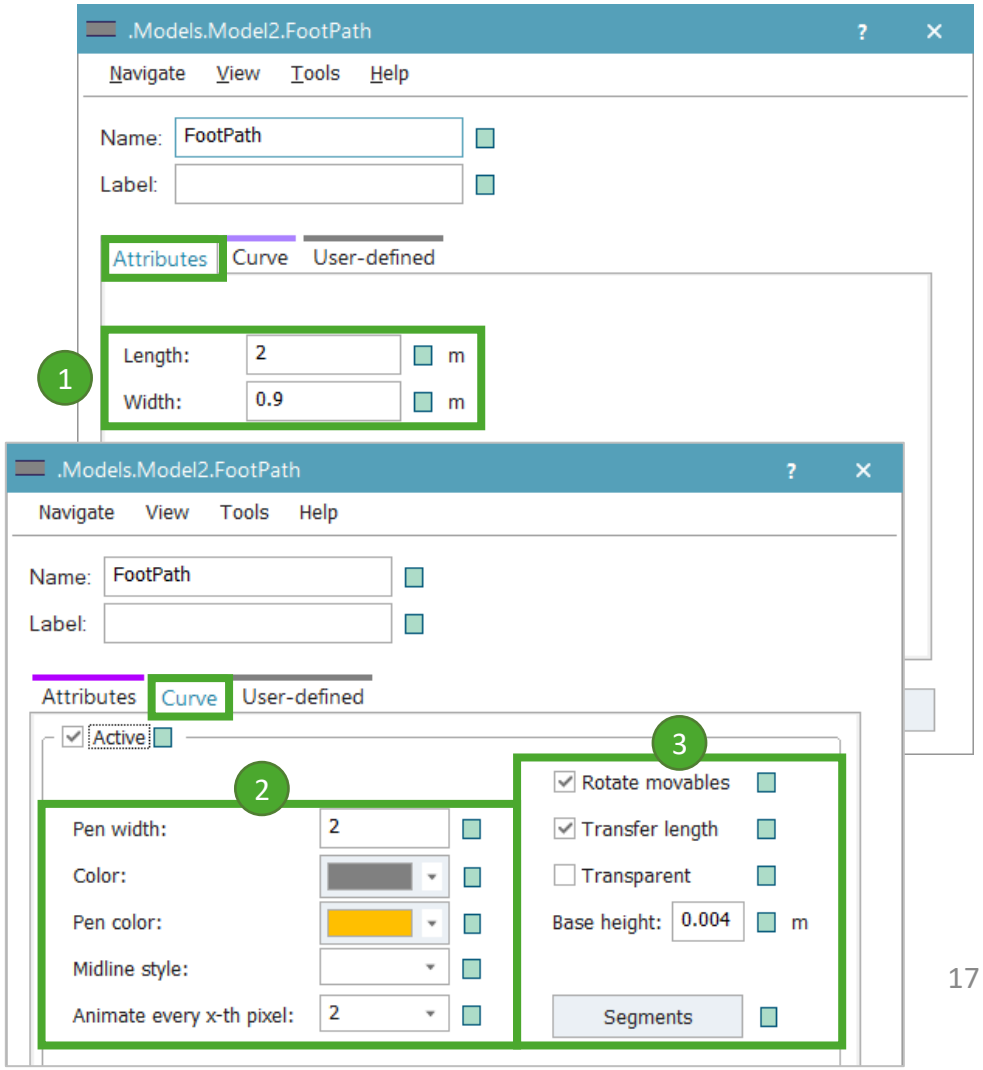


Standard Objects of Plant Simulation

ŠKODA AUTO University

Footpath

- Icon 
- The object defines a path, which is used for movement of “Workers” between individual “Workplaces”.
- It is the length-oriented object. The path and width length can be defined via the option (1).
- The options in the tab “Curve” are for setting of:
  - Graphics – length, color, animation range (2).
  - Options in category (3) allow:
    - Rotate graphics of moving MU.
    - To adopt the length of the object according to its size in the “Frame”.
    - Graphics transparency.
    - “Segments” allow manual size adjustment of “FoothPath”.

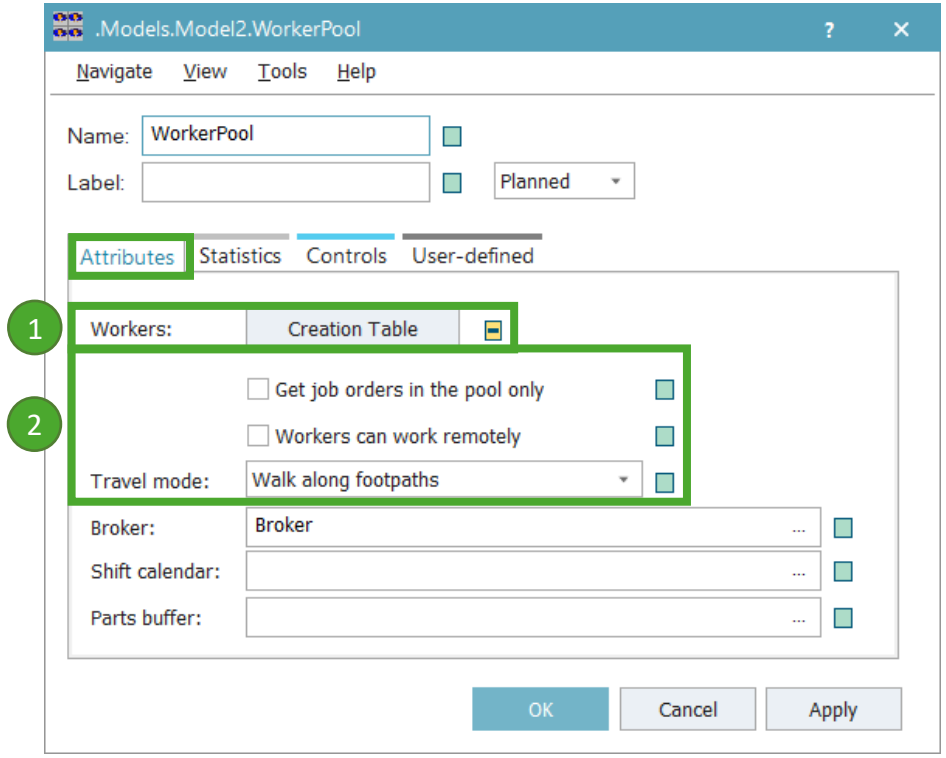


Standard Objects of Plant Simulation

ŠKODA AUTO University

WorkerPool

- Icon 
- ”Workers” are generated in the space defined by the object. These are waiting in the time when none of orders is available.
- The option ”Creation Table” (1) ensures generating and assigning of workers, speed and shift mode.
- Options (2) define:
  - The order can be assigned only in “Workerpool” (worker has to return to WorkerPool) or elsewhere.
  - Worker can work remotely (e.g. if the workplace is occupied by another worker).
  - Method of transferring the worker to the workplace with/without using “FootPath”.

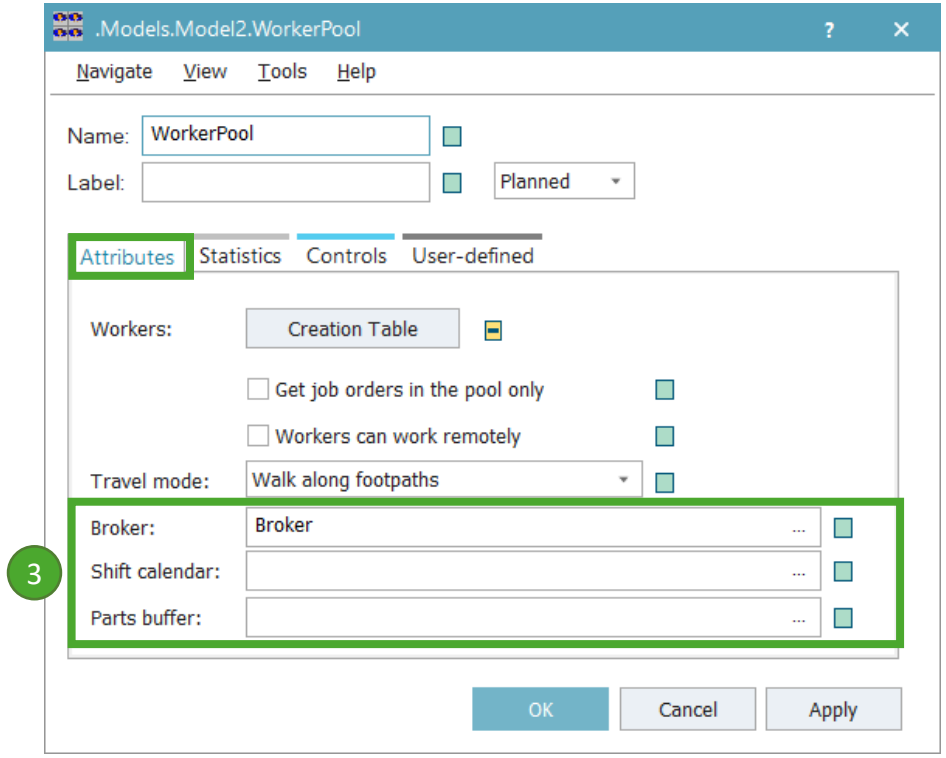


Standard Objects of Plant Simulation

ŠKODA AUTO University

WorkerPool

- Icon 
- Options (3) assign:
  - “Broker” to the given “Workerpool”.
  - “Shift calendar”.
  - “PartsBuffer” is the place, where a worker can leave a part in case the shift is over.



Standard Objects of Plant Simulation

ŠKODA AUTO University

Worker

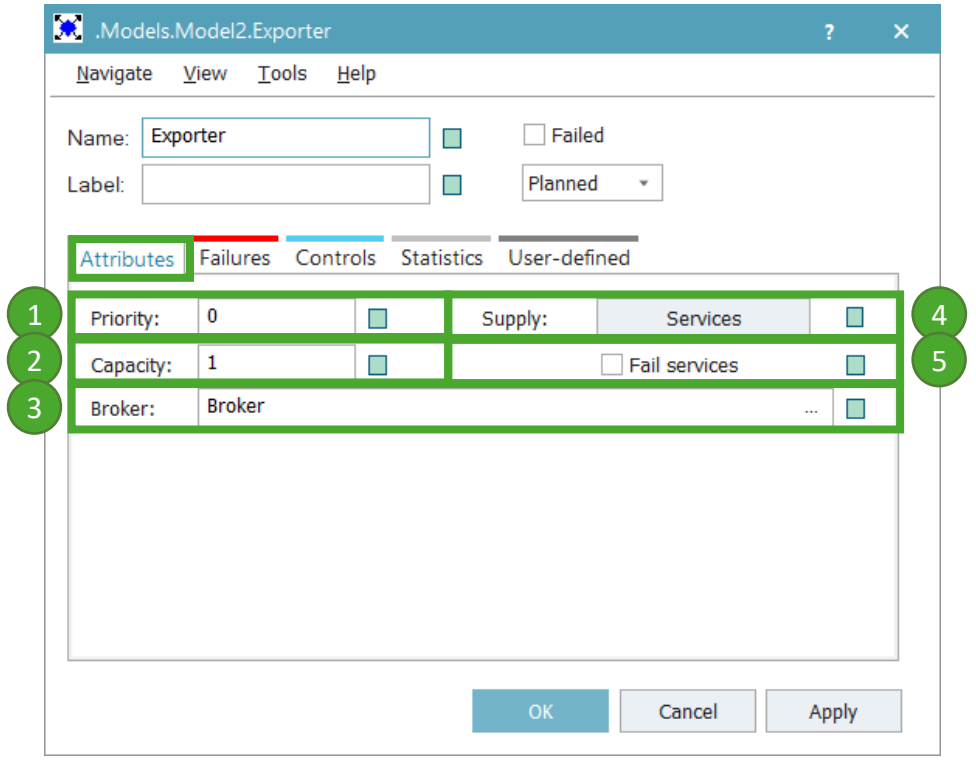
- Icon 
- It represents mobile object, which is able to work on the object “WorkPlace”.
- It is possible to use it for objects:
  - Station.
  - ParallelStation.
  - AssemblyStation.
  - DismatleStation.
- Worker is located in “Workerpool” in the time, when he/she is not working.
- Worker moves via “Footpath” between “Workplace” or straight.
- It is possible to set his/her speed on “Footpath”, number of parts he/she is able to carry (Capacity) etc.

Standard Objects of Plant Simulation

ŠKODA AUTO University

Exporter

- Icon 
- The object represents export service. It cooperates with “Broker”, tab „Importer” and tab „Failure Importer” in objects Station, ParallelStation, AssemblyStation and DismantleStation.
- Exporter offers service, which is provided to Importers.
- The option “Priority” (1) sets preferences of individual exporters. Higher values has the preference.
- “Capacity” (2) defines the maximal number of exported services.
- “Broker” (3) represents a Broker, which should provide the service.
- The button “Services” (4) allows to choose a service, which will be provided by Exporter. The exporter performs the services based on the list in the table.



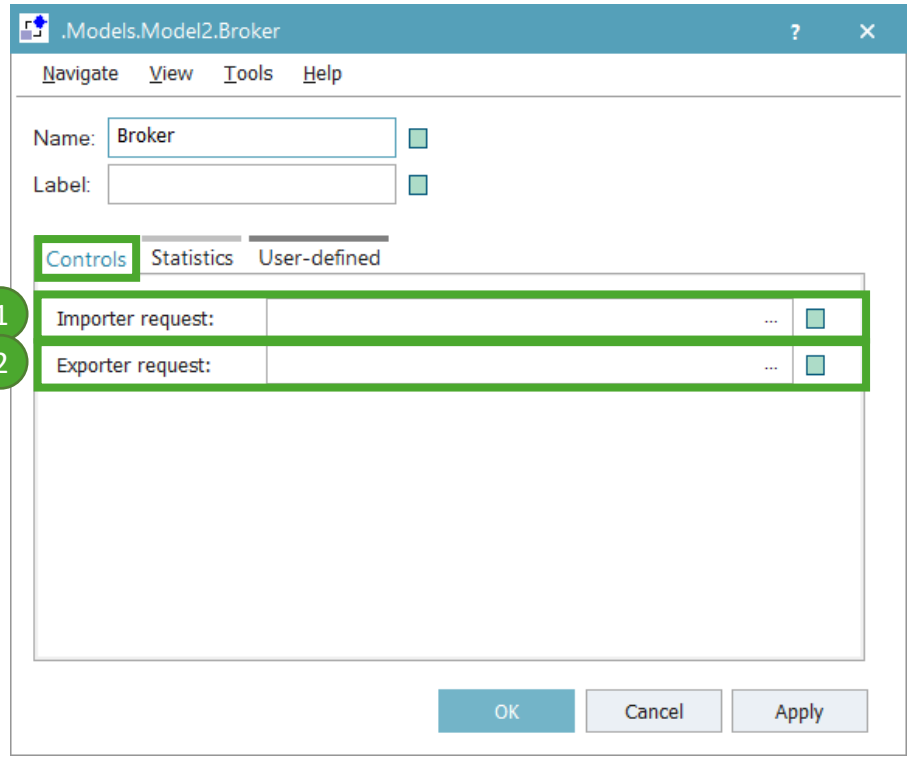
- When the box “Fail services” (5) is activated, it allows to pause work of exporter by failures. New requirements cannot be satisfied during the failure.

Standard Objects of Plant Simulation

ŠKODA AUTO University

Broker

- Icon 
- The object represents a go-between for offered and demanded services.
- Each “Broker” can cooperate with several Exporters, who offer services, and can accept demands from several importers, who need services.
- The options (1) and (2) represent possibilities of assigning custom strategies to importers and exporters via method.

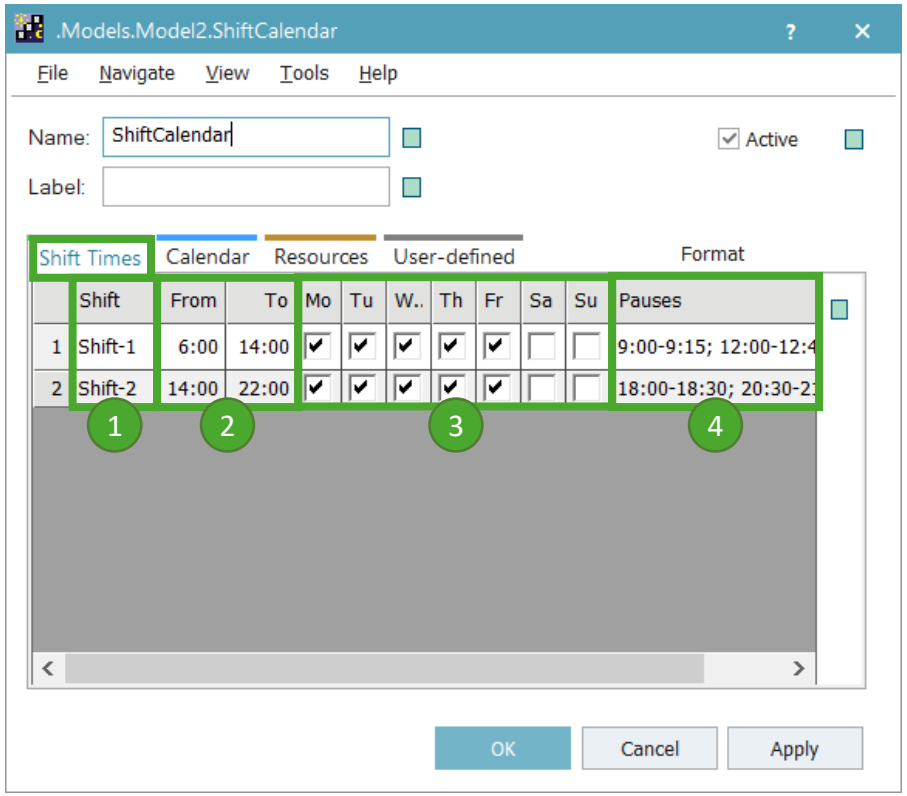


Standard Objects of Plant Simulation

ŠKODA AUTO University

ShiftCalendar

- Icon 
- Object defines a shift calendar to individual objects.
- It is possible to define:
  - Number of shifts (1).
  - Their range (2).
  - Working days and free days (3).
  - Breaks (4).
- Assignment of calendar to specific object can be done in the tab “Controls” of the object by moving the calendar into text box “ShiftCalendar”, or in opposite way, by moving the object onto the ShiftCalendar.
- The object then works only at selected times.

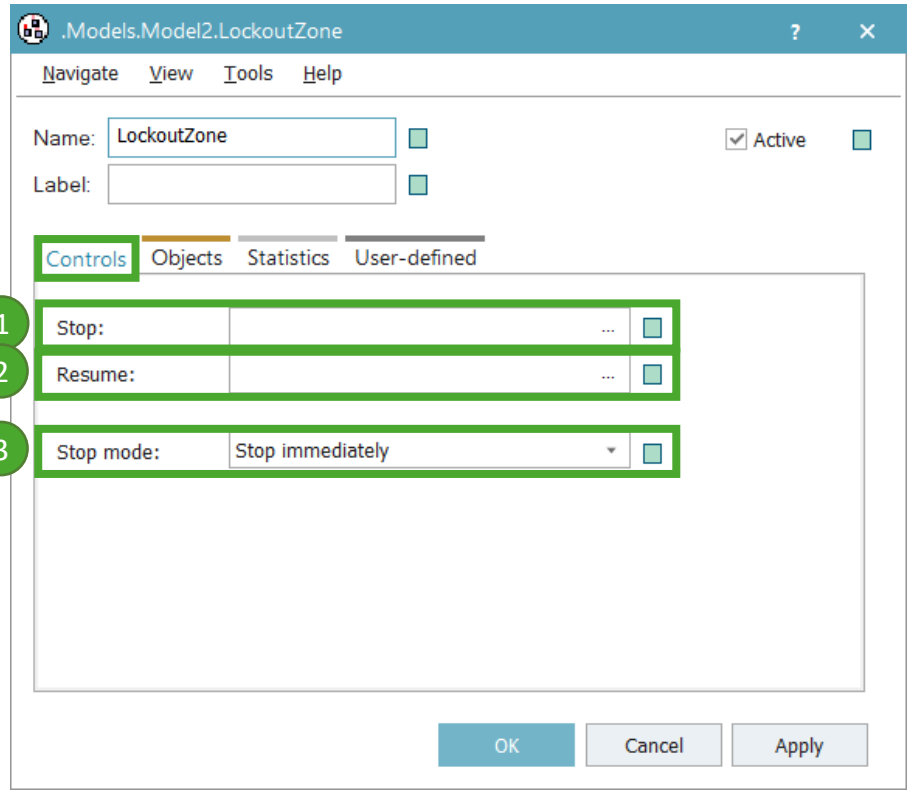


Standard Objects of Plant Simulation

ŠKODA AUTO University

LockoutZone

- Icon 
- The object groups several individual objects. In case of one machine's failure the others stop as well.
- In case of a failure, on all stations the option "Stopped" → TRUE is activated.
- "Stop" (1) is user-defined method, which is started at the beginning of a failure (Stopped = TRUE).
- "Resume" (2) is user-defined method, which is started at the end of a failure (Stopped = FALSE).
- "Stop mode" (3) can be set to immediate stop or to stop at the moment, when the service is available.



Standard Objects of Plant Simulation

ŠKODA AUTO University

Method

- Icons 

- Objects of the group “Information Flow”.
- Zero capacity.
- Methods are short parts of program, comparable to procedures or functions in programming languages Basic, Pascal or C++. The programming language “SimTalk” used in Plant Simulation was developed from the programming language “Eiffel” and it is very similar to other programming languages.
- A method is made up from standard methods, key words, assignments and control structures. The list of methods applicable to an object and suggestible attributes can be displayed in context menu ⇒ Show Attributes and Methods.
- In addition, any number of attributes can be defined and affected.
- Object “Method” is fully integrated into the object-oriented concept of Plant Simulation. The compiler processes source code during the simulation run (some methods are processed on the beginning of the simulation run – “Init”, some of them at the end of the simulation run – “EndSim” and some of them reset the variables – “Reset”).
- More information in lectures with the topic of SimTalk methods and language.

Standard Objects of Plant Simulation

ŠKODA AUTO University

Variable (data types)

- Icon 
- Data types defines ranges of data values, which are in objects as parameters, input data or variables.
- By default, Plant Simulation offers the following data types:

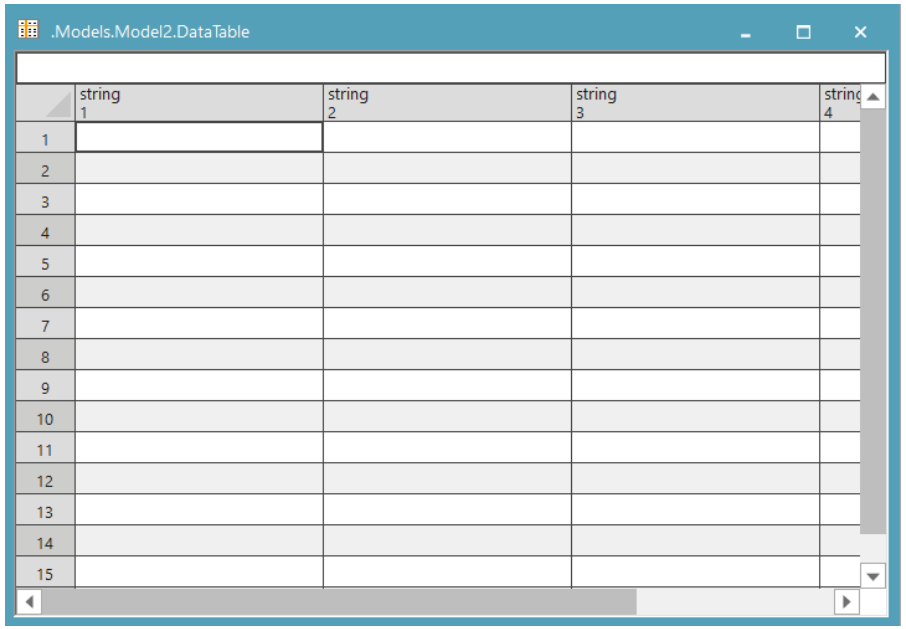
boolean	TRUE or FALSE
integer	0, 1, 2, …
real, length, weight, speed, money	number with float decimal point
string	sequence of characters
date	date with the format (rrrr/mm/dd)
time	time with the format (hh:mm:ss.ssss)
datetime	date and time with format (rrrr/mm/dd hh:mm:ss.ssss)
list, stack, queue	list with the one column (queue - FIFO, stack - LIFO)
table	table with more columns
object	link to the object

Standard Objects of Plant Simulation

ŠKODA AUTO University

DataTable

- Icon 
- Object of the group “Information Flow”.
- Zero capacity.
- It is a list of values, which contains two or more rows. It’s typical a possibility of individual access to it, i.e., we can address exactly the requirements based on column or row index.
- Rows and columns can be changed, added and deleted during the simulation run.
- Embedded tables can be created by the system of tables, so multidimensional variable can be created (multidimensional field).
- Table can be formatted according its use.
- It is possible to define a number of columns and rows, to assign data type and allowed range of values for individual columns, different access rights, provide the table with column and row index for higher table transparency etc.

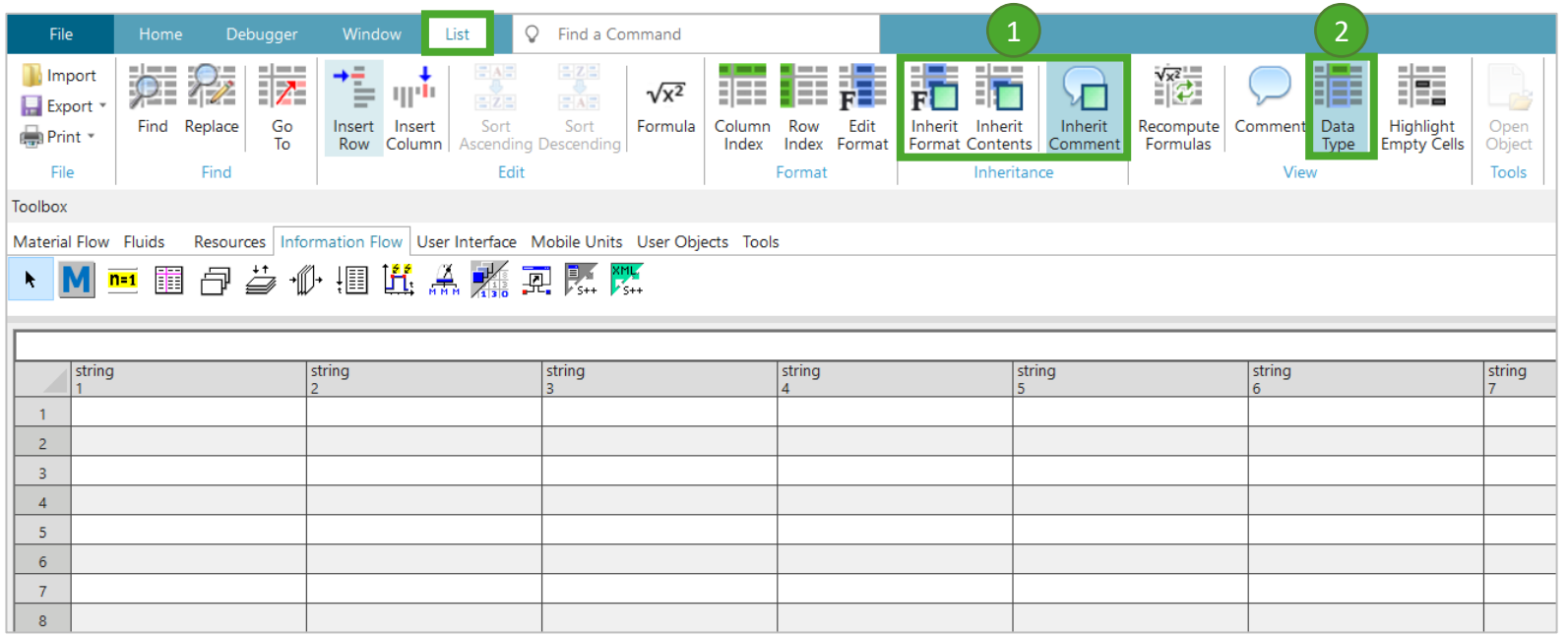


Standard Objects of Plant Simulation

ŠKODA AUTO University

DataTable (inheritance)

- Icon 
- After inserting the table into the frame from the Toolbox, format inheritance – “Inherit Format “, or content inheritance – “Inherit Contents“ in the menu, or comment inheritance – “Inherit Comment“ (1) can be activated/deactivated.
- Afterwards, it is possible to change the format (2), e.g. change of default data type of all columns – String.

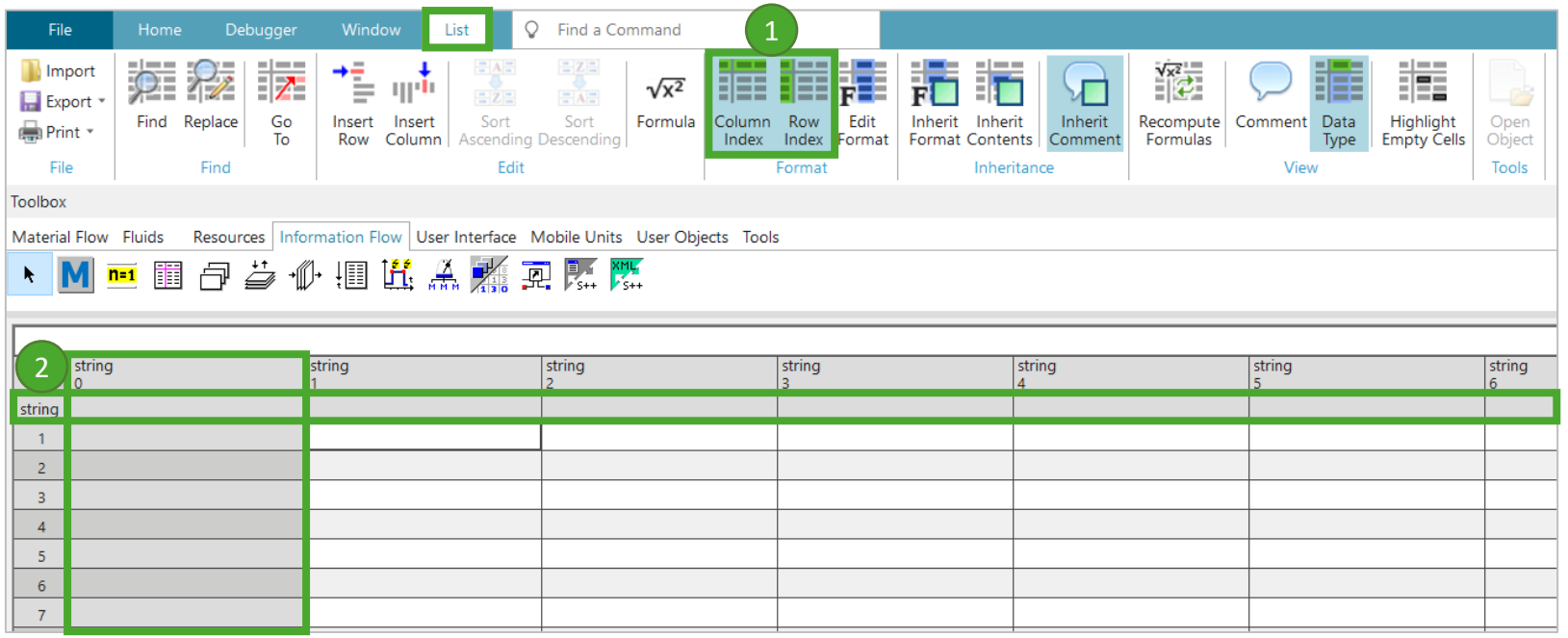


Standard Objects of Plant Simulation

ŠKODA AUTO University

DataTable (column and row index)

- Icon 
- For better clarity it is better to activate a column or row index (“Column Index“, “Row Index“) (1). This makes it possible to fill row and column headers.
- The column and row index is marked by the black border and it always has the label 0, i.e. zero column or zero row (2).

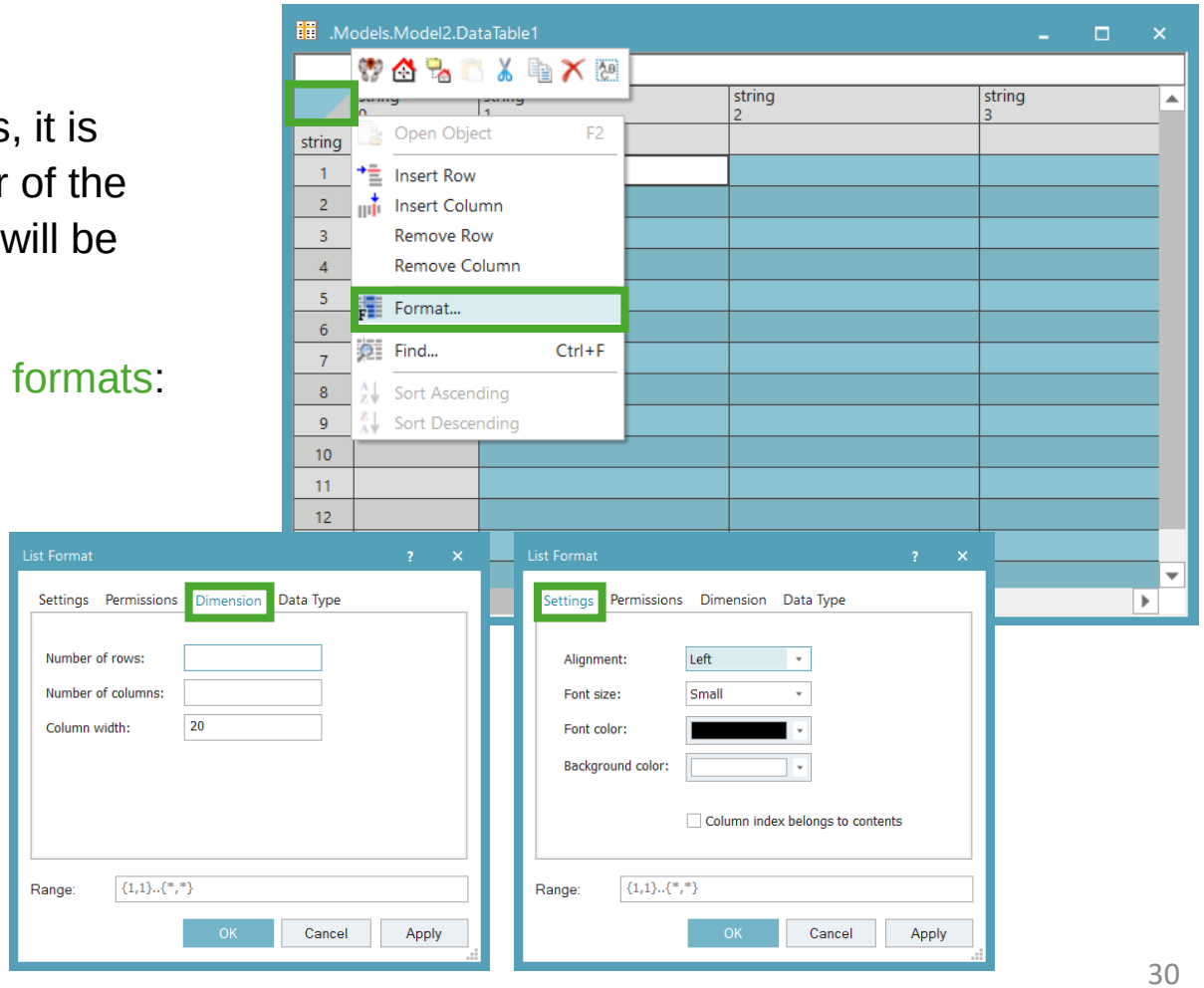


Standard Objects of Plant Simulation

ŠKODA AUTO University

DataTable (table dimensions)

- Icon 
- For changes related to the whole table, e.g. its dimensions, it is necessary to mark the whole table by the left-upper corner of the table – by clicking there the whole table, without headers, will be marked (will become blue).
- In menu “Format…“ there can be the most important table formats:
  - dimension – number of rows, columns (if we want to limit it for some reason),
  - settings – alignment, font color and font size, background color,
  - permissions – reading / writing access.

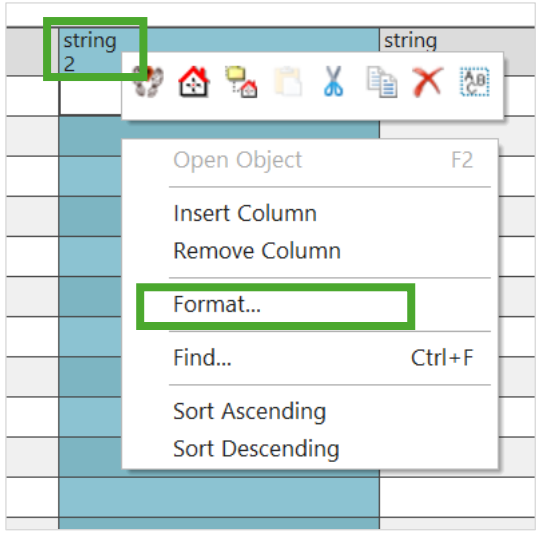


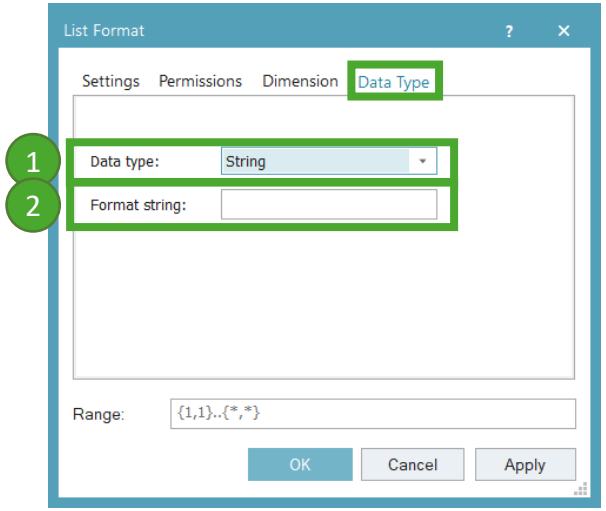
Standard Objects of Plant Simulation

ŠKODA AUTO University

DataTable (data type)

- Icon 
- Data type of column can be changed if we will mark the header and in menu “Format…“ there we set the requested type, then confirm the changes via “Apply“ and close the menu via “OK“.
- Available data types (1) – boolean, integer, real, string, object, table, list, stack, queue, time, money, length, weight, speed, acceleration, data and datetime.
- For data types integer, real, length, weight, speed, acceleration, money and string it is possible to limit data inserting in dialog via Format string (2) (character sequence format) (e.g. **A** - only letters, **C** – only capital letters and numbers, **N** – only numbers.
- Format string **“-15.2**” for data type real means that number can have 15 digits in total and 2 digits of them are after the decimal point, the sign “-” means that negative numbers are possible).



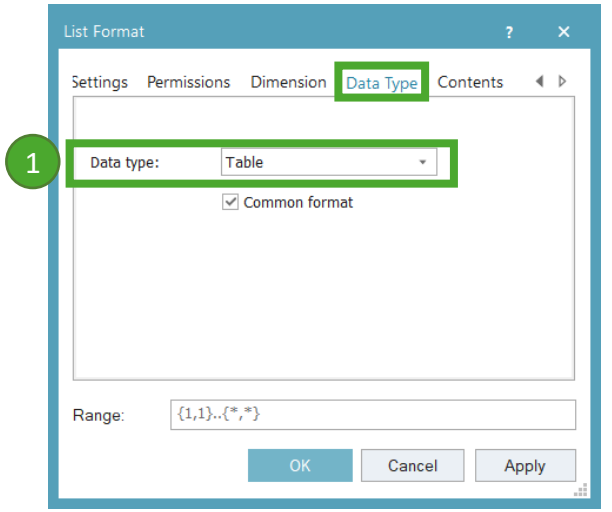


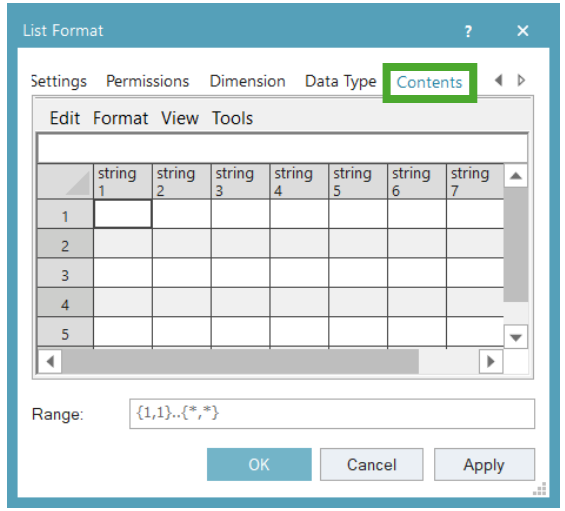
Standard Objects of Plant Simulation

ŠKODA AUTO University

DataTable (embedded table)

- Icon 
- If we choose data type “Table” for a column, we are inserting another table into the table – embedded table.
- This embedded table can be formatted in the tab Table Format.
- Each row of that column represents another table. If the option Common format is activated, all of the embedded tables in particular column will have the same format.
- Embedded table can be opened through context menu (via right-clicking select command menu) or via F2 button, in case the cursor is in the particular row and that cell is not empty (just to write “x”).





Thank you for attention

Jan Fábry

Department of Production, Logistics and Quality Management

fabry@savs.cz www.janfabry.cz

www.savs.cz