

**Supplementary Material**  
**Only for Review Process**

# Supplementary material for review process: Systems Documentation

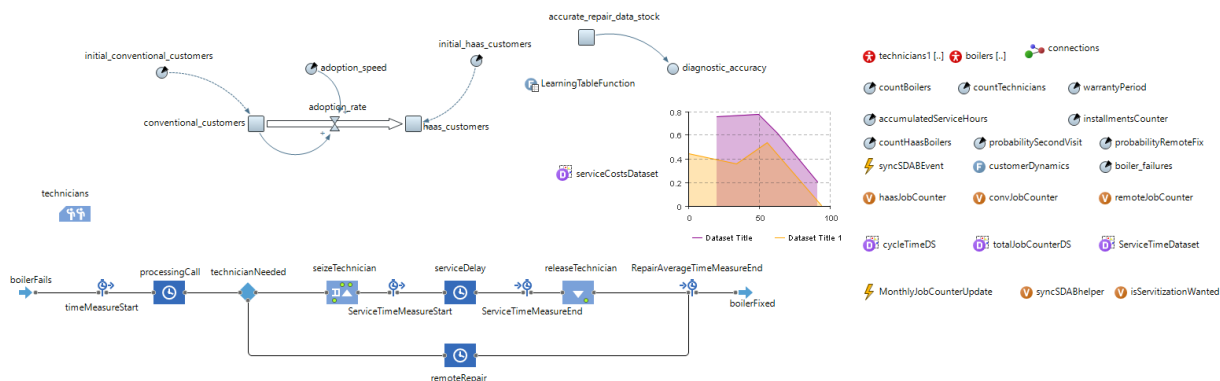
## Model: Model revision nr 6

Name	Value
General	
Model time units	days
Numerical methods	
Differentiation Equations Method	Euler
Algebraic Equations Method	Modified Newton
Mixed Equations Method	RK45+Newton
Absolute accuracy	1.0E-5
Time accuracy	1.0E-5
Relative accuracy	1.0E-5
Fixed time step	0.001
Advanced	
Java package name	model2
File Name	C:\Users\rpwa02\Models\Model revision nr 6\Model revision nr 6.alp

## Agent Type: Main

Description: we start with 30minutes,

Name	Value
Agent in flowcharts	
Use in flowcharts as	Agent
On seize resource	send("go",unit);
Dimensions and movement	
Speed	(10 : MPS)
Rotate animation towards movement	true
Rotate vertically as well (along Z-axis)	false
Space and network	
Space Type	Continuous
Dynamic: Width	800
Dynamic: Height	800
Dynamic: z Height	0
Layout Type	Random
Layout Type Apply On Startup	true
Network type	User-defined
Network Type Apply On Startup	true
Enable steps	false
Advanced Java	
Import	import com.querydsl.core.types.dsl.MathExpressions;
Generic	false
Advanced	
Logging	true
Auto-create datasets	true
AOC_DATASETS_UPDATE_TIME_PROPERTIES	- Recurring Event Properties
Limit the number of data samples	false
Description	
Description	we start with 30minutes,



### Scale: scale

Name	Value
General	
Unit	meters
Scale	10.0
Type	Defined graphically
Length, pixels	100.0
Show at runtime	false
Lock	false
Public	false
Position and size	
x	0.0
y	-150.0
Rotation	0.0

### Parameter: probabilityRemoteFix

Description: The probability that a failure of a Haas boiler can be fixed remotely with IoT technology.

Name	Value
General	
Array	false
Default value	0.3
Type	double
Show at runtime	true
Show name	true
Value editor	
Label	probabilityRemoteFix

Name	Value
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	The probability that a failure of a HaaS boiler can be fixed remotely with IoT technology.

## Parameter: probabilitySecondVisit

Description: the probability that a boiler repair will include a second visit.

Name	Value
General	
Array	false
Default value	0.7
Type	double
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	the probability that a boiler repair will include a second visit.

## Parameter: countBoilers

Description: this parameter determines the number of boilers at the start of the simulations.

Name	Value
General	
Array	false
Default value	5
Type	int
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	this parameter determines the number of boilers at the start of the simulations.

## Parameter: countHaasBoilers

Description: This parameter determines the number of HaaS boilers at the start of the simulations.

Name	Value
------	-------

Name	Value
General	
Array	false
Default value	1
Type	int
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	This parameter determines the number of HaaS boilers at the start of the simulations.

## Parameter: initial\_conventional\_customers

Description: Number of conventional customers at the beginning of the simulation

Name	Value
General	
Array	false
Default value	100000
Type	int
Show at runtime	false
Show name	true
Value editor	
Label	initial_conventional_customers
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	Number of conventional customers at the beginning of the simulation

## Parameter: initial\_haas\_customers

Description: Number of HaaS customers at the beginning of the simulation

Name	Value
General	
Array	false
Default value	0
Type	int
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false

Name	Value
Save in snapshot	true
Description	
Description	Number of HaaS customers at the beginning of the simulation

## Parameter: boiler\_failures

Description: variable for tracking the number of failed boilers

Name	Value
General	
Array	false
Type	double
Show at runtime	false
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	variable for tracking the number of failed boilers

## Parameter: adoption\_speed

Description: speed at which

Name	Value
General	
Array	false
Default value	0
Type	double
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	speed at which

## Parameter: warrantyPeriod

Name	Value
General	
Array	false
Type	double
Show at runtime	true
Show name	true
Value editor	

Name	Value
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true

## Parameter: accumulatedServiceHours

Description: this variables trick the number of accumulated number of work time by the engineers.

Name	Value
General	
Array	false
Default value	0
Type	double
Show at runtime	true
Show name	true
Value editor	
Label	parameter
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	this variables trick the number of accumulated number of work time by the engineers.

## Parameter: installmentsCounter

Description: this counter tracks the number of installed HaaS boilers. It gets incremented in boilerStatechar: fix.

Name	Value
General	
Array	false
Type	double
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	this counter tracks the number of installed HaaS boilers. It gets incremented in boilerStatechar: fix.

## Parameter: countTechnicians

Description: This parameter determines the number of technicians at the start of the simulations.

Name	Value
General	
Array	false

Name	Value
Default value	5000
Type	int
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	This parameter determines the number of technicians at the start of the simulations.

## Function: customerDynamics

Description: the function synchronises the SD customer stocks with the boiler agent stock.

Name	Value
General	
Return type:	Just action (returns nothing)
Show at runtime	true
Show name	true
Function body	
Body	<pre>if(boilers.haasCustomers() &lt; haas_customers){   isServitizationWanted = true; } else{   isServitizationWanted = false; }</pre>
Advanced	
Access type	public
System dynamics units	false
Description	
Description	the function synchronises the SD customer stocks with the boiler agent stock.

## Table Function: LearningTableFunction

Description: this table function is represents the organisations learning curve. It is assumed that 10000 recorded repair cases are necessary in order increase diagnostic accuracy to 99%

Name	Value
General	
Out of range behavior	Nearest
Interpolation	Linear
Show at runtime	false
Show name	true
Table data	
Load From Database	false
Advanced	
Access type	public
System dynamics units	true
Unit	repairs



Name	Value
Description	
Description	this table function is represents the organisations learning curve. It is assumed that 10000 recoreded repair cases are necessary in order increase diagnostic accuracy to 99%

**Table Data:**

Argument	Value
0.0	0.5
100.0	0.55
300.0	0.6
700.0	0.65
1500.0	0.7
3100.0	0.75
6300.0	0.8
10000.0	0.99

**Event: syncSDABEvent**

Description: this is a cyclical occurring event calling the customerDynamic function.

Name	Value
General	
Logging	true
EVENT_TIMEOUT_PROPERTIES	- Recurring Event Properties
Mode	Cyclic
Trigger type	Timeout
Show at runtime	true
Show name	true
Action	
Action	customerDynamics();
Description	
Description	this is a cyclical occurring event calling the customerDynamic function.

**Event: MonthlyJobCounterUpdate**

Name	Value
General	
Logging	true
EVENT_TIMEOUT_PROPERTIES	- Recurring Event Properties
Mode	Cyclic
Trigger type	Timeout
Show at runtime	true
Show name	true
Action	
Action	//ConvJobCounterDataset.add(this.dateToTime(this.date()),this.convJobCounter);convJobCounter=0; //HaasJobCounterDataset.add(this.dateToTime(this.date()),this.haasJobCounter);haasJobCounter=0; //RemoteJobCounterDataset.add(this.dateToTime(this.date()),this.remoteJobCounter);remoteJobCounter=0; //DiagnosticAccuracyDataset.add(this.dateToTime(this.date()),this.diagnostic_accuracy);

Name	Value
	<pre>//TechnicianUtilisationDataset.add(this.dateToTime(this.date()),this.technicians.utilization());technicians.resetStats(); //HaaSCustomersDataset.add(this.dateToTime(this.date()),this.boilers.haaSCustomers()); //CycleTimeDataset.add(this.dateToTime(this.date()),this.RepairAverageTimeMeasureEnd.dataset.getYMean());//this.RepairAverageTimeMeasureEnd.resetStats(); //ServiceTimeDataset.add(this.dateToTime(this.date()),this.ServiceTimeMeasureEnd.dataset.getYMean());//this.ServiceTimeMeasureEnd.resetStats(); cycleTimeDS.add(this.dateToTime(this.date()),this.RepairAverageTimeMeasureEnd.dataset.getYMean());this.RepairAverageTimeMeasureEnd.resetStats(); totalJobCounterDS.add(this.dateToTime(this.date()),this.convJobCounter + this.haaSJobCounter +this.remoteJobCounter);convJobCounter=0;haaSJobCounter=0;remoteJobCounter=0; serviceCostsDataset.add(this.dateToTime(this.date()),this.accumulatedServiceHours + this.installmentsCounter*1000);</pre>

### Variable: syncSDABhelper

Name	Value
General	
Initial value	initial_haaS_customers
Type	double
Show at runtime	true
Show name	true
Advanced	
Access type	public
Constant	false
Save in snapshot	true
System dynamics units	false

### Variable: haaSJobCounter

Description: this counter gets incremented by seizeTechnician, and track the number of HaaS jobs.

Name	Value
General	
Initial value	0
Type	double
Show at runtime	true
Show name	true
Advanced	
Access type	public
Constant	false
Save in snapshot	true
System dynamics units	false
Description	
Description	this counter gets incremented by seizeTechnician, and track the number of HaaS jobs.

### Variable: convJobCounter

Description: this counter gets incremented by seizeTechnician, and track the number of conventional jobs.

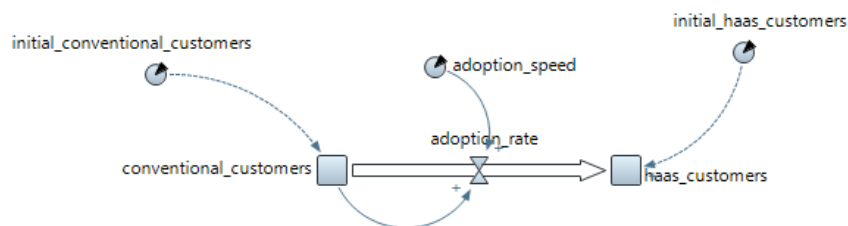
Name	Value
General	
Type	double
Show at runtime	true
Show name	true
Advanced	
Access type	public
Constant	false
Save in snapshot	true
System dynamics units	false
Description	
Description	this counter gets incremented by seizeTechnician, and track the number of conventional jobs.

### Variable: remoteJobCounter

Name	Value
General	
Initial value	0
Type	double
Show at runtime	true
Show name	true
Advanced	
Access type	public
Constant	false
Save in snapshot	true
System dynamics units	false

### Variable: isServitizationWanted

Name	Value
General	
Initial value	false
Type	boolean
Show at runtime	true
Show name	true
Advanced	
Access type	public
Constant	false
Save in snapshot	true
System dynamics units	false



## Stock: haas\_customers

Description: Stock of HaaS customers

Name	Value
General	
Equation mode	Classic
Initial value	initial_haas_customers
Array	false
Show at runtime	true
Public	false
Show name	true
Advanced	
System dynamics units	true
Unit	customers
Description	
Description	Stock of HaaS customers

## Stock: conventional\_customers

Description: Number of conventional customers at the beginning of the simulation

Name	Value
General	
Equation mode	Classic
Initial value	initial_conventional_customers
Array	false
Show at runtime	true
Public	false
Show name	true
Advanced	
System dynamics units	true
Unit	customers
Description	
Description	Number of conventional customers at the beginning of the simulation

## Flow: adoption\_rate

Description: rate at which customers switch to HaaS contract

Name	Value
General	
Formula	conventional_customers*adoption_speed
Constant	false
External	false
Array	false
Show at runtime	true
Public	false
Show name	true
Advanced	
System dynamics units	false

Name	Value
Description	
Description	rate at which customers switch to HaaS contract



## Stock: accurate\_repair\_data\_stock

Description: this stock represents the data that is collected through service repairs.

Name	Value
General	
Equation mode	Classic
Initial value	0
Array	false
Show at runtime	true
Public	false
Show name	true
Advanced	
System dynamics units	false
Description	
Description	this stock represents the data that is collected through service repairs.

## Dynamic Variable: diagnostic\_accuracy

Description: The probability that a failure is diagnosed correctly, based on data analytics, and the amount collected data.

Name	Value
General	
Formula	LearningTableFunction(accurate_repair_data_stock)
Constant	false
External	false
Array	false
Show at runtime	true
Public	false
Show name	true
Advanced	
System dynamics units	false
Description	
Description	The probability that a failure is diagnosed correctly, based on data analytics, and the amount collected data.

## Seize: seizeTechnician

Name	Value
General	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]

Name	Value
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
Initial location	
Place agent(s)	at the agent animation location
Advanced	
Show at runtime	true
Public	false
Logging	true

## Agent Parameters:

Name	Value
Seize	false
Resource sets	{ { technicians } }
Seize policy	self.SEIZE_UNITS_ONE_BY_ONE
Maximum queue capacity	true
Send seized resources	true
Destination is	self.DEST_ENTITY
Attach seized resources	false
Task priority	agent.priority;
Task may preempt	false
Task preemption policy	self.PP_NO_PREEMPTION
Customize resource choice	false
Resource selection	self.RESOURCE_SELECTION_NEAREST
Define preparation tasks by	true
Enable exit on timeout	false
Enable preemption	true
Canceled units:	self.CANCELED_UNITS_RETURN_TO_HOME_LOCATION
Forced pushing	false
Restore agent location on exit	true
Force statistics collection	false
On enter	if(agent.isConventionalBoiler){this.convJobCounter++;} ;else{this.haasJobCounter++;}
On seize unit	this.send("go",unit);
"agent1 is preferred to agent2"	false

## ResourcePool: technicians

Description: this resource pool represents the external contractors that HeatCo is using

Name	Value
General	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
Initial location	

Name	Value
Place agent(s)	at the agent animation location
<b>Advanced</b>	
Show at runtime	true
Public	false
Logging	true
<b>Description</b>	
Description	this resource pool represents the external contractors that HeatCo is using

### Agent Parameters:

Name	Value
Resource type	self.RESOURCE_MOVING
Capacity defined	self.CAPACITY_DIRECT
Capacity	countTechnicians
When capacity decreases	false
New resource unit	new model2.Technician()
Speed	0.1
Home location is	self.HOME_SINGLE_NODE
Home location (nodes)	{ HQ }
Specified by	self.DOWNTIME_LIST
'End of shift' priority	100
'End of shift' may preempt	true
'End of shift' preemption policy	self.PP_NO_PREEMPTION
Add units to:	false
Force statistics collection	true
On seize	send("seized",unit);unit.job=agent;unit.probDiagnosisCorrect=randomTrue(diagnostic_accuracy);unit.travelTime=uniform(30,60);
On release	send("released",unit);

### Technician: technicians1

Description: HeatCo works with external technicians. We assume a boiler/technician ratio of 200/1. Meaning the service requests of 200 boilers can be managed by one technician.

Name	Value
<b>General</b>	
Replication	countTechnicians
Initialization Type	Contains a given number of agents
Population of agents	true
Replication	countTechnicians
Initialization Type	Contains a given number of agents
Population of agents	true
Show name	true
<b>Initial location</b>	
Place agent(s)	at the agent animation location
<b>Statistics</b>	
Statistics	[counterRepairing - Agent Statistics, counterSecondVisit - Agent Statistics, counterTravel - Agent Statistics, counterIdle - Agent Statistics]
<b>Advanced</b>	

Name	Value
Show at runtime	true
Public	false
Embedded object collection type	Access by index (ArrayList)
Logging	true
Description	
Description	HeatCo works with external technicians. We assume a boiler/technician ratio of 200/1. Meaning the service requests of 200 boilers can be managed by one technician.

### Agent Parameters:

Name	Value
diagnosticAccuracyForJob	0.7

### Population Statistics:

Name	Type	Expression	Condition
counterRepairing	count		item.technicianStatechart.isStateActive(Technician.Repairing)
counterSecondVisit	count		item.technicianStatechart.isStateActive(Technician.secondVisit)
counterTravel	count		item.technicianStatechart.isStateActive(Technician.Travel)
counterIdle	count		item.technicianStatechart.isStateActive(Technician.Idle)

### Release: releaseTechnician

Description: on release the service costs are calculated. A technicians hourly wage is 18.2£.

Name	Value
General	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
Initial location	
Place agent(s)	at the agent animation location
Advanced	
Show at runtime	true
Public	false
Logging	true
Description	
Description	on release the service costs are calculated. A technicians hourly wage is 18.2£.

### Agent Parameters:

Name	Value
Release	self.ALL



## Agent Parameters:

Name	Value
Moving resources	true
Wrap-up (e.g. move home)	self.WRAP_UP_ALWAYS
'Wrap-up' usage statistics are:	self.USAGE_BUSY
On enter	<pre>this.accumulatedServiceHours = this.accumulatedServiceHours + ServiceTimeMeasureEnd.dataset.getY(ServiceTime MeasureEnd.dataset.size()-1)*18.2*24; //serviceHoursDataset.add(this.dateToTime(this.date( )),ServiceTimeMeasureEnd.dataset.getY(ServiceTim eMeasureEnd.dataset.size()-1)*18.2*24);</pre>

## Delay: processingCall

Description: This time delay represents the time it takes for a customer to call and report a failure.

Name	Value
General	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
Initial location	
Place agent(s)	at the agent animation location
Advanced	
Show at runtime	true
Public	false
Logging	true
Description	
Description	This time delay represents the time it takes for a customer to call and report a failure.

## Agent Parameters:

Name	Value
Type	self.TIMEOUT
Delay time	triangular( 5, 15, 30 )
Maximum capacity	true
Forced pushing	false
Restore agent location on exit	true
Force statistics collection	false

## TimeMeasureStart: timeMeasureStart

Description: This time measure is used for the whole cycle time

Name	Value
General	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true

Name	Value
Initial location	
Place agent(s)	at the agent animation location
Advanced	
Show at runtime	true
Public	false
Logging	true
Description	
Description	This time measure is used for the whole cycle time

## SelectOutput: technicianNeeded

Description: the distribution depends on diagnostic accuracy and repair instructions (from SD model: after 1 year: impact of data only, after 10 year impact of improved design and data), as well as the design,

Name	Value
General	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
Initial location	
Place agent(s)	at the agent animation location
Advanced	
Show at runtime	true
Public	false
Logging	true
Description	
Description	the distribution depends on diagnostic accuracy and repair instructions (from SD model: after 1 year: impact of data only, after 10 year impact of improved design and data), as well as the design,

## Agent Parameters:

Name	Value
Select True output	false
Condition	agent.isConventionalBoiler    (!agent.isConventionalBoiler && randomTrue( 1- probabilityRemoteFix ))

## Delay: remoteRepair

Description: HaaS boilers are digitalised and enable remote fixing of minor failures.

Name	Value
General	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
Initial location	
Place agent(s)	at the agent animation location

Name	Value
Advanced	
Show at runtime	true
Public	false
Logging	true
Description	
Description	HaaS boilers are digitalised and enable remote fixing of minor failures.

### Agent Parameters:

Name	Value
Type	self.TIMEOUT
Delay time	triangular( 45,75,60 )
Capacity	1
Maximum capacity	false
Forced pushing	false
Restore agent location on exit	true
Force statistics collection	false
On enter	remoteJobCounter++;

### Boiler: boilers

Name	Value
General	
Replication	initial_conventional_customers
Initialization Type	Contains a given number of agents
Population of agents	true
Replication	initial_conventional_customers
Initialization Type	Contains a given number of agents
Population of agents	true
Show name	true
Initial location	
Place agent(s)	at the agent animation location
Statistics	
Statistics	[haasCustomers - Agent Statistics, convBoilersAgeStat - Agent Statistics, haasBoilersAgeStat - Agent Statistics, convCustomers - Agent Statistics]
Advanced	
Show at runtime	true
Public	false
Embedded object collection type	Access by index (ArrayList)
Logging	true

### Agent Parameters:

Name	Value
priority	1
boilerAge	this.addToDate(this.date(), YEAR,uniform(-15,0));
parameter	true
timeToFailure	0

### Population Statistics:

Name	Type	Expression	Condition
------	------	------------	-----------

## Population Statistics:

Name	Type	Expression	Condition
haasCustomers	count		!item.isConventionalBoiler
convBoilersAgeStat	average	differenceInCalendarUnits(YEAR,item.boilerAge,this.date())	item.isConventionalBoiler
haasBoilersAgeStat	average	differenceInCalendarUnits(YEAR,item.boilerAge,this.date())	!item.isConventionalBoiler
convCustomers	count		item.isConventionalBoiler

## Enter: boilerFails

Description: boiler entity enters if it is failing.

Name	Value
<b>General</b>	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: Boiler]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: Boiler]
Show name	true
<b>Initial location</b>	
Place agent(s)	at the agent animation location
<b>Advanced</b>	
Show at runtime	true
Public	false
Logging	true
<b>Description</b>	
Description	boiler entity enters if it is failing.

## Agent Parameters:

Name	Value
New location	self.LOCATION_NOT_SPECIFIED
Change dimensions	false
Add newborns to:	false
Forced pushing	true
On enter	boiler_failures++;

## Exit: boilerFixed

Description: if the boiler unit leaves the exit the data stock accurate\_repair\_data\_stock increments.

Name	Value
<b>General</b>	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
<b>Initial location</b>	

Name	Value
Place agent(s)	at the agent animation location
<b>Advanced</b>	
Show at runtime	false
Public	false
Logging	true
<b>Description</b>	
Description	if the boiler unit leaves the exit the data stock accurate_repair_data_stock increments.

### Agent Parameters:

Name	Value
On exit	accurate_repair_data_stock=accurate_repair_data_stock + 1;

### Delay: serviceDelay

Description: the delay starts when the technician receives the request and ends when he fixed the problem.

Name	Value
<b>General</b>	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
<b>Initial location</b>	
Place agent(s)	at the agent animation location
<b>Advanced</b>	
Show at runtime	true
Public	false
Logging	true
<b>Description</b>	
Description	the delay starts when the technician receives the request and ends when he fixed the problem.

### Agent Parameters:

Name	Value
Type	self.MANUAL
Maximum capacity	true
Forced pushing	false
Restore agent location on exit	true
Force statistics collection	false

### TimeMeasureEnd: RepairAverageTimeMeasureEnd

Description: This time measure is used for the whole cycle time

Name	Value
<b>General</b>	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false

Name	Value
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
Initial location	
Place agent(s)	at the agent animation location
Advanced	
Show at runtime	true
Public	false
Logging	true
Description	
Description	This time measure is used for the whole cycle time

### Agent Parameters:

Name	Value
TimeMeasureStart blocks	{ timeMeasureStart }
Dataset capacity	1000000

### TimeMeasureStart: ServiceTimeMeasureStart

Description: this measure is used for the time a technician is actively working.

Name	Value
General	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
Initial location	
Place agent(s)	at the agent animation location
Advanced	
Show at runtime	true
Public	false
Logging	true
Description	
Description	this measure is used for the time a technician is actively working.

### TimeMeasureEnd: ServiceTimeMeasureEnd

Description: this measure is used for the time a technician is actively working.

Name	Value
General	
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Population of agents	false
Generic Parameters Substitutes	[Generic Parameter Substitute: ]
Show name	true
Initial location	
Place agent(s)	at the agent animation location
Advanced	
Show at runtime	true

Name	Value
Public	false
Logging	true
Description	
Description	this measure is used for the time a technician is actively working.

### Agent Parameters:

Name	Value
TimeMeasureStart blocks	{ ServiceTimeMeasureStart }
Dataset capacity	10000000

### Time Plot: plot

Name	Value
General	
Lock	false
Public	true
Data update	
Analysis auto update	true
ANALYSIS_UPDATE_TIME_PROPERTIES	- Recurring Event Properties
Dataset Samples To Keep	100
Scale	
Time window	100
Time	model time units
Vertical scale	Auto
Appearance	
Labels horizontal position	DEFAULT
Labels vertical position	DEFAULT
Label format	Model time units
Labels Text Color	darkGray
Chart Area Grid Color	darkGray
Draw line	true
Fill area under line	true
Interpolation	Linear
Position and size	
x	840.0
Width	260.0
y	150.0
Height	210.0
Legend	
Show legend	true
Legend size	30.0
Legend text color	black
Chart area	
Chart Area: X Offset	50.0
Chart Area: Width	180.0
Chart Area: Y Offset	30.0
Chart Area: Height	120.0
Chart Area: Background Color	white

Name	Value
Chart area border color	black
Advanced	
Time window moves	Continuously
Show name	false
Logging	true

Plot Items:

Title	Type	Dataset / Value	Point Style	Color	Line	Width	Interpolation
Dataset Title	value	diagnostic_accuracy	NONE	darkMagenta	true	1.0	LINEAR
Dataset Title 1	value	0	NONE	orange	true	1.0	LINEAR

### Data Set: ServiceTimeDataset

Description: This dataset records the average time for service work every month.

Name	Value
General	
Dataset Samples To Keep	100000
Axis Data Freeze X Axis	true
Show at runtime	true
Show name	true
Data update	
Analysis auto update	false
Logging	true
Description	
Description	This dataset records the average time for service work every month.

### Data Set: serviceCostsDataset

Name	Value
General	
Dataset Samples To Keep	100000
Axis Data Freeze X Axis	true
Show at runtime	true
Show name	true
Data update	
Analysis auto update	false
Logging	true

### Data Set: totalJobCounterDS

Description: This dataset records the total number of service jobs for every month of the simulation.

Name	Value
General	
Dataset Samples To Keep	10000
Axis Data Freeze X Axis	true
Show at runtime	true
Show name	true
Data update	



Name	Value
Analysis auto update	false
Logging	true
Description	
Description	This dataset records the total number of service jobs for every month of the simulation.

## Data Set: cycleTimeDS

Description: This dataset records the avergae RepairAverageTimeMeasure for every month of the simulation.

Name	Value
General	
Dataset Samples To Keep	10000
Axis Data Freeze X Axis	true
Show at runtime	true
Show name	true
Data update	
Analysis auto update	false
Logging	true
Description	
Description	This dataset records the avergae RepairAverageTimeMeasure for every month of the simulation.

## Agent Presentation: seizeTechnician\_presentation

Name	Value
General	
Show at runtime	true
Public	true
Position and size	
x	0.0
y	0.0
z	0.0
Rotation	0.0
Scale	Automatically calculated
Advanced	
Show in	2D and 3D
Draw agent with offset to this position	false
Show name	false

## Agent Presentation: technicians1\_presentation

Name	Value
General	
Show at runtime	false
Public	true
Position and size	
x	1830.0
y	-400.0
z	0.0
Rotation	0.0

Name	Value
Scale	Automatically calculated
Advanced	
Show in	2D and 3D
Draw agent with offset to this position	false
Show name	false

## Agent Presentation: boilers\_presentation

Name	Value
General	
Show at runtime	false
Public	true
Position and size	
x	1800.0
y	-400.0
z	0.0
Rotation	0.0
Scale	Automatically calculated
Advanced	
Show in	2D and 3D
Draw agent with offset to this position	false
Show name	false

## Link to agents: connections

Name	Value
General	
Show at runtime	true
Show name	true
Communication	
Message type	Object
Animation	
Draw line	false

## Agent Type: Boiler

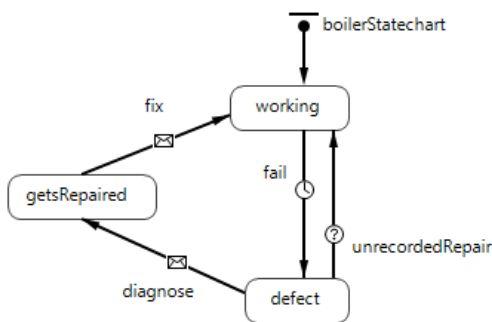
Name	Value
Agent in flowcharts	
Use in flowcharts as	Agent
Dimensions and movement	
Speed	(10 : MPS)
Rotate animation towards movement	true
Rotate vertically as well (along Z-axis)	false
Space and network	
Space Type	Continuous
Advanced Java	
Generic	false
Advanced	
Logging	true

Name	Value
Auto-create datasets	true
AOC_DATASETS_UPDATE_TIME_PROPERTIES	- Recurring Event Properties
Limit the number of data samples	false

main

connections

()



- boilerAge
- timeToFailure
- color
- priority
- servitizeContract
- isConventionalBoiler

## Scale: scale

Name	Value
General	
Unit	meters
Scale	10.0
Type	Defined graphically
Length, pixels	100.0
Show at runtime	false
Lock	false
Public	false
Position and size	
x	0.0
y	-150.0
Rotation	0.0

## Parameter: priority

Description: conventional boiler: priority = 1, haas boiler priority = 2

Name	Value
General	
Array	false
Type	double
Show at runtime	true
Show name	true

Name	Value
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	conventional boiler: priority = 1, haas boiler priority = 2

## Parameter: boilerAge

Description: boiler age is set when boiler gets created or replace on equals the date.

Name	Value
General	
Array	false
Type	Date
Show at runtime	true
Show name	true
Value editor	
Editor control	Days/Weeks
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	boiler age is set when boiler gets created or replace on equals the date.

## Parameter: isConventionalBoiler

Name	Value
General	
Array	false
Default value	true
Type	boolean
Show at runtime	true
Show name	true
Value editor	
Label	parameter
Editor control	Check Button
Advanced	
System dynamics units	false
Save in snapshot	true

## Parameter: timeToFailure

Description: randomly defined time until boiler fails

Name	Value
General	
Array	false
Default value	triangular(0,18-differenceInCalendarUnits(YEAR,boilerAge,this.

Name	Value
	<code>date()),limitMin(15-differenceInCalendarUnits(YEAR,boilerAge,this.date()),0))</code>
Type	double
Show at runtime	true
Show name	true
Value editor	
Label	timeToFailure
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true
Description	
Description	randomly defined time until boiler fails

## Function: servitizeContract

Name	Value
General	
Return type:	Just action (returns nothing)
Show at runtime	true
Show name	true
Function body	
Body	<code>isConventionalBoiler = false; priority = 2; color=GREEN;</code>
Advanced	
Access type	default
System dynamics units	false

## Variable: color

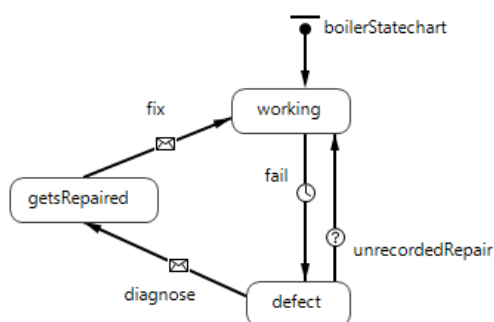
Name	Value
General	
Initial value	BLACK
Type	Color
Show at runtime	true
Show name	true
Advanced	
Access type	public
Constant	false
Save in snapshot	true
System dynamics units	false

## Statechart Entry Point: boilerStatechart

Description: the boiler state chart shows the states boiler agents move through

Name	Value
General	
Logging	true

Name	Value
Action	<pre> if(differenceInCalendarUnits(YEAR,boilerAge,this.date()) &gt; 12) { timeToFailure = triangular(0,18- differenceInCalendarUnits(YEAR,boilerAge,this.date()),limitMin(15- differenceInCalendarUnits(YEAR,boilerAge,this.date()),0)); } else { timeToFailure = triangular(0,12- differenceInCalendarUnits(YEAR,boilerAge,this.date()),limitMin(10- differenceInCalendarUnits(YEAR,boilerAge,this.date()),0)); } //traceln(differenceInCalendarUnits(YEAR,boilerAge,this.date())+" "+timeToFailure);                     </pre>
Show at runtime	true
Show name	true
Description	
Description	the boiler state chart shows the states boiler agents move through



### Transition: fail

Name	Value
General	
Action	<pre> if (!isConventionalBoiler    differenceInCalendarUnits(YEAR,boilerAge,this.date())&lt;this.get_Ma in().warrantyPeriod) {main.boilerFails.take(this);} //if (differenceInCalendarUnits(YEAR,this.date(),boilerAge)&lt;5){color=B                     </pre>
Timeout	(timeToFailure : YEAR)
Trigger type	Timeout
Show name	true

### Transition: diagnose

Name	Value
General	
Action	<pre> //traceln(differenceInCalendarUnits(YEAR,boilerAge,this.date())+" "+isConventionalBoiler+" "+timeToFailure);                     </pre>
Equals	"here"
Filter Type	On particular message
Message type	Object
Trigger type	Message
Show name	true

### Transition: fix

Name	Value
General	
Action	<pre> //traceln(differenceInCalendarUnits(YEAR,boilerAge,this.date()))+" "+isConventionalBoiler+" "+timeToFailure); if (differenceInCalendarUnits(YEAR,boilerAge,this.date())&gt;12)//when a boiler is older than 12 yo it gets replaced {  boilerAge=this.date(); timeToFailure=triangular(0,12,10); if (randomTrue(this.get_Main().adoption_speed) &amp;&amp; this.get_Main().conventional_customers &gt;= 1 ) {  //new boiler installment causes costs this.get_Main().installmentsCounter++;  if(isConventionalBoiler &amp;&amp; this.get_Main().conventional_customers &gt;= 1){ this.servitizeContract(); this.get_Main().haas_customers++; this.get_Main().conventional_customers--; } }  } else //next failure depends on age { timeToFailure = triangular(0,6,5); //traceln(differenceInCalendarUnits(YEAR,boilerAge,this.date()))+" "+isConventionalBoiler+" "+timeToFailure); </pre>
Equals	"fixed"
Filter Type	On particular message
Message type	String
Trigger type	Message
Show name	true

## Transition: unrecordedRepair

Name	Value
General	
Action	<pre> //traceln(differenceInCalendarUnits(YEAR,boilerAge,this.date()))+" "+isConventionalBoiler+" "+timeToFailure); if (differenceInCalendarUnits(YEAR,boilerAge,this.date())&gt;12) // older than 12 yo gets replaced not repaired { boilerAge=this.date(); timeToFailure=triangular(0,12,10);  if (this.get_Main().isServitizationWanted &amp;&amp; this.get_Main().conventional_customers &gt;= 1) { this.servitizeContract(); this.get_Main().installmentsCounter++;  } } else // boiler is younger than 12yo and gets repaired but next failure will come earlier { timeToFailure=triangular(0,6,5);  } </pre>
Condition	<pre> isConventionalBoiler &amp;&amp; differenceInCalendarUnits(YEAR,boilerAge,this.date())&gt;= this.get_Main().warrantyPeriod //boiler is out of warranty </pre>

Name	Value
Trigger type	Condition
Show name	true

## State: working

Description: the boiler is functioning

Name	Value
General	
Entry action	<code>if(!isConventionalBoiler){color = GREEN;}else {color = WHITE;} //if(differenceInCalendarUnits(YEAR,boilerAge,this.date())&gt;5){color =GRAY;}</code>
Fill color	white
Show name	true
Description	
Description	the boiler is functioning

## State: defect

Description: the boiler does not function

Name	Value
General	
Entry action	<code>if(!isConventionalBoiler){color = PURPLE;} else{color = RED;}</code>
Fill color	white
Show name	true
Description	
Description	the boiler does not function

## State: getsRepaired

Description: a technician is on sight and repairs the boiler

Name	Value
General	
Entry action	color=gold;
Fill color	white
Show name	true
Description	
Description	a technician is on sight and repairs the boiler

## Rounded Rectangle: roundRectangle

Name	Value
General	
Show at runtime	true
Lock	false



Name	Value
Embedded icon	false
Public	true
Appearance	
Fill color	white
Dynamic: Fill Color	color
Line color	black
Line width	1.0
Line style	SOLID
Position and size	
x	-10.0
Width	10.0
y	-10.0
Height	20.0
Rotation	0.0
Radius	10.0
Advanced	
Show name	false

## Link to agents: connections

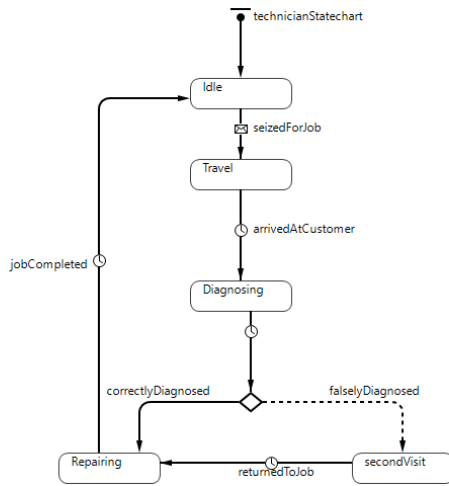
Name	Value
General	
Show at runtime	true
Show name	true
Communication	
Message type	Object
Animation	
Draw line	false

## Agent Type: Technician

Name	Value
Agent in flowcharts	
Use in flowcharts as	Agent
Dimensions and movement	
Speed	(0.01 : MPS)
Rotate animation towards movement	false
Space and network	
Space Type	Continuous
Advanced Java	
Import	import org.eclipse.jetty.http.DateGenerator;
Generic	false
Advanced	
Logging	true
Auto-create datasets	true
AOC_DATASETS_UPDATE_TIME_PROPERTIES	- Recurring Event Properties
Limit the number of data samples	false

main

connections



- job color
- diagnosticAccuracyForJob probDiagnosisCorrect
- travelTime

### Scale: scale

Name	Value
General	
Unit	meters
Scale	10.0
Type	Defined graphically
Length, pixels	100.0
Show at runtime	false
Lock	false
Public	false
Position and size	
x	0.0
y	-150.0
Rotation	0.0

### Parameter: job

Name	Value
General	
Array	false
Type	Agent
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	

Name	Value
System dynamics units	false
Save in snapshot	true

## Parameter: diagnosticAccuracyForJob

Name	Value
General	
Array	false
Type	double
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true

## Parameter: travelTime

Name	Value
General	
Array	false
Type	double
Show at runtime	true
Show name	true
Value editor	
Editor control	Text
Advanced	
System dynamics units	false
Save in snapshot	true

## Variable: color

Name	Value
General	
Initial value	BLACK
Type	Color
Show at runtime	true
Show name	true
Advanced	
Access type	public
Constant	false
Save in snapshot	true
System dynamics units	false

## Variable: probDiagnosisCorrect

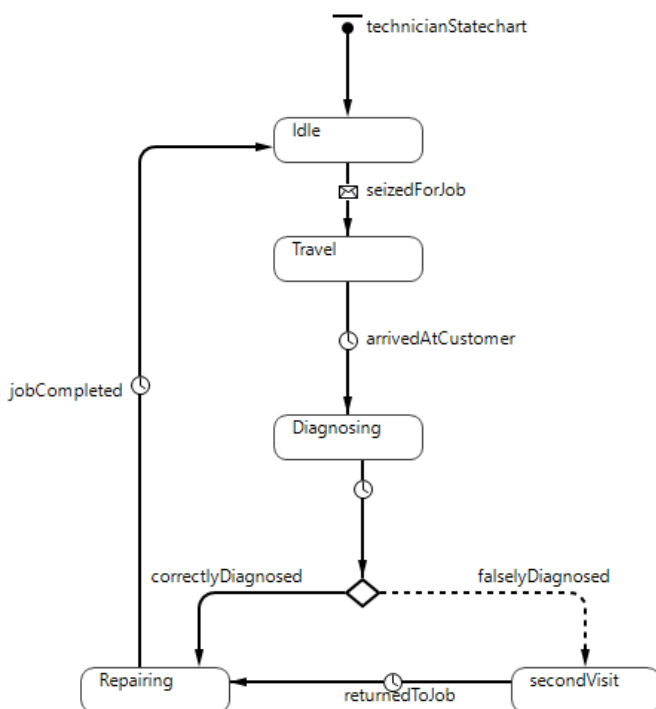
Name	Value
General	

Name	Value
Type	boolean
Show at runtime	true
Show name	true
Advanced	
Access type	public
Constant	false
Save in snapshot	true
System dynamics units	false

## Statechart Entry Point: technicianStatechart

Description: the statechart shows the state an external party technician goes through during a service job

Name	Value
General	
Logging	true
Show at runtime	true
Show name	true
Description	
Description	the statechart shows the state an external party technician goes through during a service job



## Transition: seizedForJob

Description: the technician received a job from HeatCo

Name	Value
General	
Equals	"seized"
Filter Type	On particular message

Name	Value
Message type	String
Trigger type	Message
Show name	true
Description	
Description	the technician received a job from HeatCo

## Transition: arrivedAtCustomer

Name	Value
General	
Action	send("here",job)
Timeout	(travelTime : MINUTE)
Trigger type	Timeout
Show name	true

## Transition: transition3

Description: diagnosis is assumed to take ten minutes. Afterwards,

Name	Value
General	
Timeout	(15 : MINUTE)
Trigger type	Timeout
Show name	false
Description	
Description	diagnosis is assumed to take ten minutes. Afterwards,

## Transition: correctlyDiagnosed

Name	Value
General	
Condition	probDiagnosisCorrect == true
Default Transition	false
Show name	true

## Transition: jobCompleted

Name	Value
General	
Action	send("fixed",job);this.get_Main().serviceDelay.stopDelay(job);
Timeout	(triangular( 1, 5, 2 ) : HOUR)
Trigger type	Timeout
Show name	true

## Transition: falselyDiagnosed

Name	Value
General	
Action	send("secondVisit",job);moveTo(this.get_Main().SparePartsInventoryPointNode);

Name	Value
Default Transition	true
Show name	true

## Transition: returnedToJob

Name	Value
General	
Action	color=PURPLE;moveTo(job);
Timeout	(1 : DAY)
Trigger type	Timeout
Show name	true

## State: Idle

Description: the engineer does nothing

Name	Value
General	
Entry action	color=BLACK;
Fill color	white
Show name	true
Description	
Description	the engineer does nothing

## State: Travel

Description: the technician travels to the customer site

Name	Value
General	
Entry action	color=BLUE;
Fill color	white
Show name	true
Description	
Description	the technician travels to the customer site

## State: Diagnosing

Description: the technician diagnoses the failure mode

Name	Value
General	
Fill color	white
Show name	true
Description	
Description	the technician diagnoses the failure mode

## State: Repairing

Description: the technicians fixes the failure mode

Name	Value
------	-------

Name	Value
General	
Entry action	color=LIME;
Fill color	white
Show name	true
Description	
Description	the technicians fixes the failure mode

## State: secondVisit

Description: a second visit occurs when a failure gets misdiagnosed and the technician needs to revisit

Name	Value
General	
Entry action	color=RED;
Fill color	white
Show name	true
Description	
Description	a second visit occurs when a failure gets misdiagnosed and the technician needs to revisit

## Branch: branch

Name	Value
General	
Show name	false

## Group: person

Name	Value
General	
Show at runtime	true
Lock	false
Embedded icon	false
Public	true
Position and size	
x	0.0
y	0.0
z	0.0
Rotation	0.0
Advanced	
Show in	2D only
Show name	false

## Curve: shapeBody

Name	Value
General	
Polyline closed	true
Show at runtime	true

Name	Value
Lock	false
Public	true
Appearance	
Fill color	black
Dynamic: Fill Color	color
Line width	1.0
Line style	SOLID
Position and size	
x	-2.0
y	-7.0
Advanced	
Control points are set automatically	true
Show name	false

## Link to agents: connections

Name	Value
General	
Show at runtime	true
Show name	true
Communication	
Message type	Object
Animation	
Draw line	false

## Parameter Variation Experiment: AdoptionWarrantyParameterVariation


Name	Value
General	
Maximum available memory	16384
Agent type	Main
Model time	
Stop option	Stop at specified time
Initial time	0.0
Final time	6570.0
Initial date	Thu May 14 00:00:00 GMT 2020
Randomness	
Random Number Generation Type	Random seed (unique simulation runs)
Selection mode for simultaneous events	LIFO (in the reverse order of scheduling)
Replications	
Use replications	false
Window	
Title	Model7 : ParametersVariation
Enable zoom and panning	true
Enable developer panel	true
Show developer panel on start	false
Java actions	
After simulation run	excelSimulationResults.setCellValue("warranty:"+root.



Name	Value
	<pre>warrantyPeriod,this.getCurrentIteration(),1,1); excelSimulationResults.setCellValue("init customers:"+root.initial_conventional_customers,this.getCurrentIteration(),2,1); excelSimulationResults.setCellValue("adoption speed:"+root.adoption_speed,this.getCurrentIteration(),3,1);  excelSimulationResults.setCellValue("Maintenance Costs",this.getCurrentIteration(),1,2); excelSimulationResults.writeDataSet(root.serviceCostsDataset,this.getCurrentIteration(),1,3);  excelSimulationResults.setCellValue("avg cycle time",this.getCurrentIteration(),1,8); excelSimulationResults.writeDataSet(root.cycleTimeDS,this.getCurrentIteration(),1,9);  excelSimulationResults.setCellValue("service requests",this.getCurrentIteration(),1,11); excelSimulationResults.writeDataSet(root.totalJobCounterDS,this.getCurrentIteration(),1,12);  excelSimulationResults.setCellValue("service time",this.getCurrentIteration(),1,19); excelSimulationResults.writeDataSet(root.ServiceTimeDataset,this.getCurrentIteration(),1,20);  excelSimulationResults.setCellValue("cycle time",this.getCurrentIteration(),1,22); excelSimulationResults.writeDataSet(root.ServiceTimeDataset,this.getCurrentIteration(),1,23);</pre>
<b>Advanced</b>	
Allow parallel evaluations	true
Load root from snapshot	false

Parameter Variation Experiment Parameters:

Parameter	Type	Value		
		Min	Max	Step
probabilityRemoteFix	FIXED			
probabilitySecondVisit	FIXED			
countBoilers	FIXED	0		
countHaasBoilers	FIXED	0		
initial_conventional_customers	FIXED	10000		
initial_haas_customers	FIXED			
boiler_failures	FIXED			
adoption_speed	FIXED			
warrantyPeriod	RANGE	5	10	2.5
accumulatedServiceHours	FIXED			
installmentsCounter	FIXED			
countTechnicians	FIXED	50		

 excelSimulationResults

## Excel File: excelSimulationResults

Name	Value
General	
File name	ResourceReference: model2.parameterVariations.xlsx (Resolved: true)
Show at runtime	true
Show name	true
Advanced	
Load on model startup	true
Save on model termination	true
Save in snapshot	false

## Database: Database

Name	Value
General	
Database shutdown compac	false
Log	
Logging	true