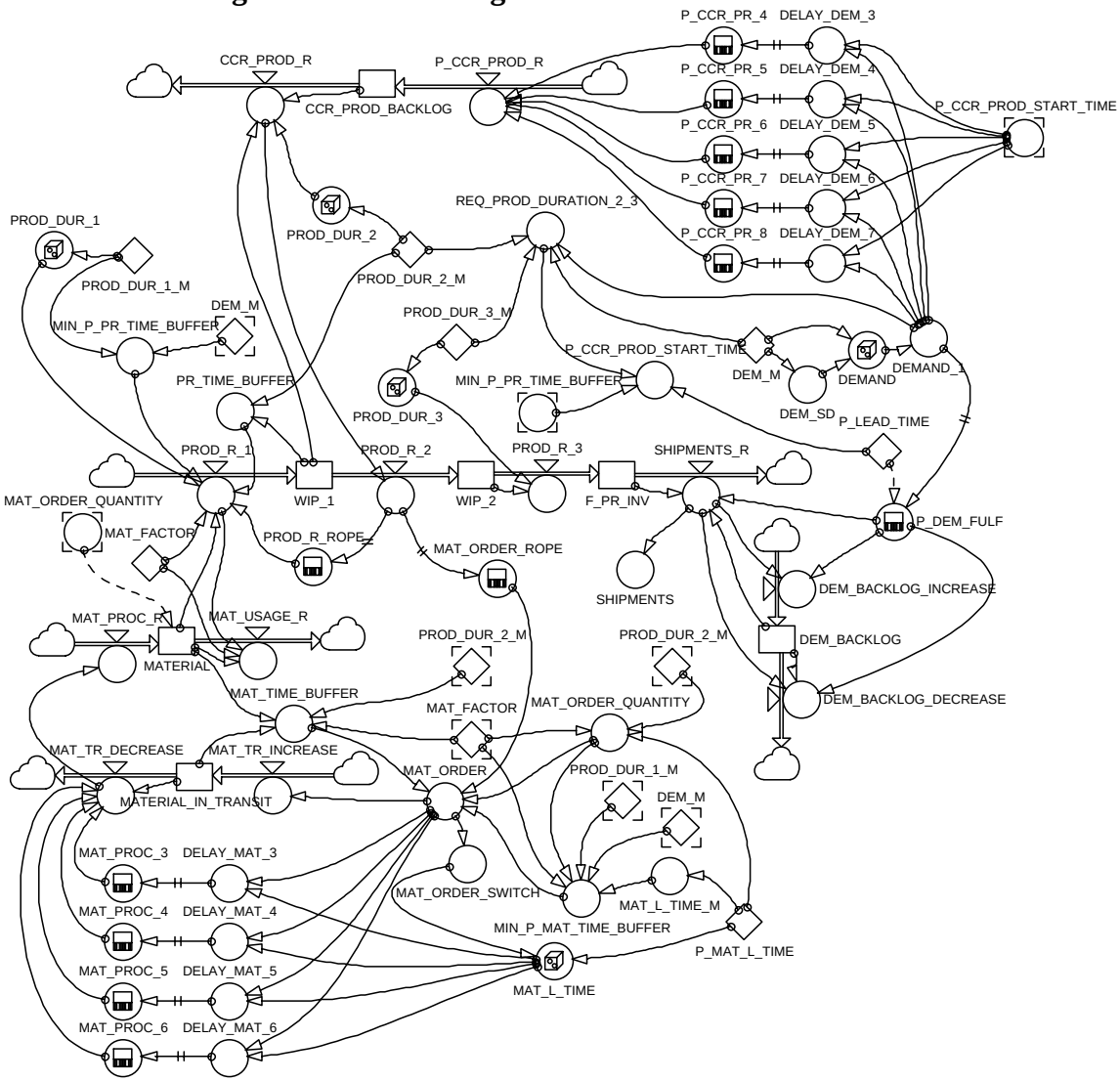
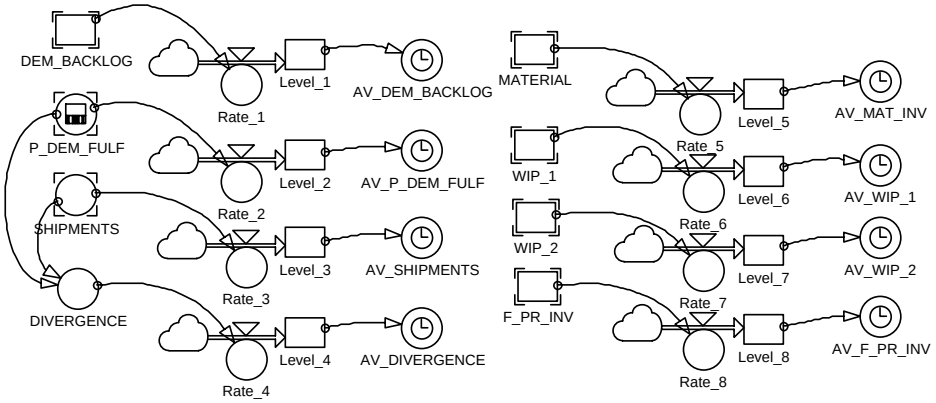
Stock-flow Diagrams and Equations Omitted from the Main Text due to File Size Limit

A. DBR approach

A.1 Stock-flow Diagram for Scheduling and Production Sector



A.2 Stock-flow Diagram for Controlling Sector



A.3 Equations

init CCR_PROD_BACKLOG = 0
flow CCR_PROD_BACKLOG = -dt*CCR_PROD_R
+dt*P_CCR_PROD_R
doc CCR_PROD_BACKLOG = This is what we have to produce at the CCR operation of the shop, in order the demand to be fulfilled at its planned lead time, considering: (i) what we want to produce at the CCR operation at the current time interval and (ii) what we wanted to produce at the CCR operation at the previous time interval and we couldn't produce due to the lack of capacity of the CCR operation.
unit CCR_PROD_BACKLOG = ITEMS

init DEM_BACKLOG = 0
flow DEM_BACKLOG = -dt*DEM_BACKLOG_DECREASE
+dt*DEM_BACKLOG_INCREASE
doc DEM_BACKLOG = This is the demand, whose fulfillment is going to be delayed (i.e. it is going to be satisfied more than 10 days after its release).
unit DEM_BACKLOG = ITEMS

init F_PR_INV = 0
flow F_PR_INV = -dt*SHIPMENTS_R+dt*PROD_R_3
doc F_PR_INV = This is the inventory of the finished product, which is available after the end operation of the shop.
unit F_PR_INV = ITEMS

init Level_1 = 0
flow Level_1 = +dt*Rate_1
doc Level_1 = This level is used to calculate the average value of the demand backlog (AV_DEM_BACKLOG).
unit Level_1 = ITEMS*days

init Level_2 = 0
flow Level_2 = +dt*Rate_2
doc Level_2 = This level is used to calculate the average value of the planned demand fulfillment (AV_P_DEM_FULF).
unit Level_2 = ITEMS

init Level_3 = 0
flow Level_3 = +dt*Rate_3
doc Level_3 = This level is used to calculate the average value of the shipments (AV_SHIPMENTS).
unit Level_3 = ITEMS

init Level_4 = 0
flow Level_4 = +dt*Rate_4
doc Level_4 = This level is used to calculate the average value of the divergence (AV_DIVERGENCE).
unit Level_4 = ITEMS

init Level_5 = 0
flow Level_5 = +dt*Rate_5
doc Level_5 = This level is used to calculate the average value of the raw material inventory (AV_MAT_INV).
unit Level_5 = Kg*DAYS

init Level_6 = 0
flow Level_6 = +dt*Rate_6
doc Level_6 = This level is used to calculate the average value of the inventory after the first operation of the flow shop (AV_WIP_1).
unit Level_6 = ITEMS*DAYS

init Level_7 = 0
flow Level_7 = +dt*Rate_7
doc Level_7 = This level is used to calculate the average value of the inventory after the second operation of the flow shop (AV_WIP_2).
unit Level_7 = ITEMS*DAYS

init Level_8 = 0
flow Level_8 = +dt*Rate_8
doc Level_8 = This level is used to calculate the average value of the finished product inventory of the flow shop (AV_F_PR_INV).
unit Level_8 = ITEMS*DAYS

init MATERIAL = 2*MAT_ORDER_QUANTITY
flow MATERIAL = -dt*MAT_USAGE_R+dt*MAT_PROC_R
doc MATERIAL = This is the current level of material inventory on hand. Its initial value is set equal to 2 times the quantity of the minimum material order.
unit MATERIAL = Kg

init MATERIAL_IN_TRANSIT = 0
flow MATERIAL_IN_TRANSIT = -dt*MAT_TR_DECREASE
+dt*MAT_TR_INCREASE
doc MATERIAL_IN_TRANSIT = This is the current level of material inventory in transit; i.e. the material inventory that has been ordered and it is expected to be delivered at the shop later. Its initial value is set equal to zero.
unit MATERIAL_IN_TRANSIT = Kg

init WIP_1 = 0
flow WIP_1 = +dt*PROD_R_1-dt*PROD_R_2
doc WIP_1 = This is the inventory available before the CCR operation of the shop.
unit WIP_1 = ITEMS

init WIP_2 = 0
flow WIP_2 = -dt*PROD_R_3+dt*PROD_R_2
doc WIP_2 = This is the inventory available after the CCR operation of the shop.
unit WIP_2 = ITEMS

aux CCR_PROD_R = MIN(CCR_PROD_BACKLOG/TIMESTEP,1/PROD_DUR_2, WIP_1/TIMESTEP)
doc CCR_PROD_R = This is what we produce at the shop's CCR operation considering what we have to produce (CCR _PROD_BACKLOG), the current capacity of the CCR operation (1/PROD_DUR_2) and the availability of work in process before the CCR operation (WIP_1).
unit CCR_PROD_R = ITEMS/DAY

aux DEM_BACKLOG_DECREASE = MIN(MAX(SHIPMENTS_R-P_DEM_FULF/TIMESTEP,0),DEM_BACKLOG/TIMESTEP)
doc DEM_BACKLOG_DECREASE = This is the demand fulfillment with delay at the current time interval; i.e. it is the demand satisfied later than 10 days (P_L_TIME) after its release.
unit DEM_BACKLOG_DECREASE = ITEMS/DAY

aux DEM_BACKLOG_INCREASE = MAX(P_DEM_FULF/TIMESTEP-SHIPMENTS_R,0)
doc DEM_BACKLOG_INCREASE = This is the invalid demand fulfillment at the current time interval; i.e. it is the demand that although has to be satisfied at the current time interval (10 days after its release), it is impossible to be satisfied on time.
unit DEM_BACKLOG_INCREASE = ITEMS/DAY

aux MAT_PROC_R = MAT_TR_DECREASE
doc MAT_PROC_R = This is the rate of the raw material procurement received; i.e. the raw material delivery at the current time interval. It is set equal to the material in transit decrease.
unit MAT_PROC_R = kg/DAY

aux MAT_TR_DECREASE = MIN(MAT_PROC_3+MAT_PROC_4 +MAT_PROC_5+MAT_PROC_6,MATERIAL_IN_TRANSIT)/TIMESTEP
doc MAT_TR_DECREASE = This is the rate of the raw material received; i.e. the raw material delivery at the current time interval.
unit MAT_TR_DECREASE = kg/DAY

aux MAT_TR_INCREASE = MAT_ORDER/TIMESTEP
doc MAT_TR_INCREASE = This is the raw material quantity ordered at the current time interval.
unit MAT_TR_INCREASE = kg/DAY

aux MAT_USAGE_R = MIN(PROD_R_1*MAT_FACTOR, MATERIAL/TIMESTEP)
doc MAT_USAGE_R = This is the rate of the raw material usage by the production at the gateway operation of the shop (PROD_R_1).
unit MAT_USAGE_R = kg/DAY

aux P_CCR_PROD_R = (P_CCR_PR_4+P_CCR_PR_5+P_CCR_PR_6 +P_CCR_PR_7+P_CCR_PR_8)/TIMESTEP
doc P_CCR_PROD_R = This is the Planned CCR Production Rate, i.e. it is what we want to produce at the shop's CCR operation, in order the demand to be fulfilled at its planned lead time.
unit P_CCR_PROD_R = ITEMS/DAY

aux PROD_R_1 = MIN(IF(PR_TIME_BUFFER>=MIN_P_PR_TIME_BUFFER, MIN(PROD_R_ROPE,1/PROD_DUR_1),1/PROD_DUR_1),MATERIAL/MAT_ FACTOR/TIMESTEP)
doc PROD_R_1 = This is what we produce at the gateway operation of the shop according to the DBR logic and Real Time methodology; i.e. the production rate at the gateway operation of the shop is equal with the production rate of the CCR at the time interval before 4 time steps, considering its production capacity and the availability of raw material required. Besides, if the current production time buffer is less than the minimum one, the production rate at the gateway operation of the shop is equal with its production capacity considering the availability of raw material required.
unit PROD_R_1 = ITEMS/DAY

aux PROD_R_2 = CCR_PROD_R
doc PROD_R_2 = This is what we produce at the shop's CCR operation.
unit PROD_R_2 = ITEMS/DAY

aux PROD_R_3 = MIN(1/PROD_DUR_3,WIP_2/TIMESTEP)
doc PROD_R_3 = This is what we produce at the third operation of the shop.
unit PROD_R_3 = ITEMS/DAY

aux Rate_1 = DEM_BACKLOG
doc Rate_1 = This rate is used to calculate the average value of the demand backlog (AV_DEM_BACKLOG).
unit Rate_1 = ITEMS

aux Rate_2 = P_DEM_FULF/TIMESTEP
doc Rate_2 = This rate is used to calculate the average value of the planned demand fulfillment (AV_P_DEM_FULF).
unit Rate_2 = ITEMS/DAY

aux Rate_3 = SHIPMENTS/TIMESTEP
doc Rate_3 = This rate is used to calculate the average value of the shipments (AV_SHIPMENTS).
unit Rate_3 = ITEMS/DAY

aux Rate_4 = DIVERGENCE/TIMESTEP
doc Rate_4 = This rate is used to calculate the average value of the divergence (AV_DIVERGENCE).
unit Rate_4 = ITEMS/DAY

aux Rate_5 = MATERIAL
doc Rate_5 = This rate is used to calculate the average value of the raw material inventory (AV_MAT_INV).
unit Rate_5 = Kg

aux Rate_6 = WIP_1
doc Rate_6 = This rate is used to calculate the average value of the inventory after the first operation of the flow shop (AV_WIP_1).
unit Rate_6 = ITEMS

aux Rate_7 = WIP_2
doc Rate_7 = This rate is used to calculate the average value of the inventory after the second operation of the flow shop (AV_WIP_2).
unit Rate_7 = ITEMS

aux Rate_8 = F_PR_INV
doc Rate_8 = This rate is used to calculate the average value of the finished product inventory of the flow shop (AV_F_PR_INV).
unit Rate_8 = ITEMS

aux SHIPMENTS_R = MIN(P_DEM_FULF+DEM_BACKLOG,F_PR_INV) /TIMESTEP
doc SHIPMENTS_R = This is the rate of demand shipments.
unit SHIPMENTS_R = ITEMS/DAY

aux AV_DEM_BACKLOG = Level_1 DIVZ0 TIME
doc AV_DEM_BACKLOG = This is the average value of the demand backlog (DEM_BACKLOG) from the simulation start up to the current time interval.
unit AV_DEM_BACKLOG = ITEMS

aux AV_DIVERGENCE = Level_4 DIVZ0 TIME
doc AV_DIVERGENCE = This is the average value of the DIVERGENCE from the simulation start up to the current time interval.
unit AV_DIVERGENCE = ITEMS/DAY

aux AV_F_PR_INV = Level_8 DIVZ0 TIME
doc AV_F_PR_INV = This is the average value of the finished product inventory (F_PR_INV) from the simulation start up to the current time interval.
unit AV_F_PR_INV = ITEMS

aux AV_MAT_INV = Level_5 DIVZ0 TIME
doc AV_MAT_INV = This is the average value of the raw material inventory on hand (MAT_INV) from the simulation start up to the current time interval.
unit AV_MAT_INV = Kg

aux AV_P_DEM_FULF = Level_2 DIVZ0 TIME
doc AV_P_DEM_FULF = This is the average value of the planned demand fulfillment (P_DEM_FULF) from the simulation start up to the current time interval.

unit AV_P_DEM_FULF = ITEMS/DAY

aux AV_SHIPMENTS = Level_3 DIVZ0 TIME
doc AV_SHIPMENTS = This is the average value of the SHIPMENTS from the simulation start up to the current time interval.
unit AV_SHIPMENTS = ITEMS/DAY

aux AV_WIP_1 = Level_6 DIVZ0 TIME
doc AV_WIP_1 = This is the average value of the inventory after the first operation of the shop (WIP_1) from the simulation start up to the current time interval.
unit AV_WIP_1 = ITEMS

aux AV_WIP_2 = Level_7 DIVZ0 TIME
doc AV_WIP_2 = This is the average value of the inventory after the second operation of the shop (WIP_2) from the simulation start up to the current time interval.
unit AV_WIP_2 = ITEMS

aux DELAY_DEM_3 = DEMAND_1*IF(P_CCR_PROD_START_TIME<=5,1,0)
doc DELAY_DEM_3 = This is the DEMAND whose production -in order to be dispatched on time- has P_CCR_PROD_START_TIME less than 5. The production of this demand has to start at the shop's CCR operation (i.e. it has to become part of the rate CCR_PROD_R) at the start of the 4th day after the current time interval. Therefore, it has to be added at the rate P_CCR_PROD_R 3 days after the current time interval.
unit DELAY_DEM_3 = ITEMS

aux DELAY_DEM_4 = DEMAND_1*IF(P_CCR_PROD_START_TIME>5 AND P_CCR_PROD_START_TIME<=6,1,0)
doc DELAY_DEM_4 = This is the DEMAND whose production -in order to be dispatched on time- has P_CCR_PROD_START_TIME more than 5 and less than 6. The production of this demand has to start at the shop's CCR operation (i.e. it has to become part of the rate CCR_PROD_R) at the start of the 5th day after the current time interval. Therefore, it has to be added at the rate P_CCR_PROD_R 4 days after the current time interval.
unit DELAY_DEM_4 = ITEMS

aux DELAY_DEM_5 = DEMAND_1*IF(P_CCR_PROD_START_TIME>6 AND P_CCR_PROD_START_TIME<=7,1,0)
doc DELAY_DEM_5 = This is the DEMAND whose production -in order to be dispatched on time- has P_CCR_PROD_START_TIME more than 6 and less than 7. The production of this demand has to start at the shop's CCR of the shop (i.e. it has to become part of the rate CCR_PROD_R) at the start of the 6th day after the current time interval. Therefore, it has to be added at the rate P_CCR_PROD_R 5 days after the current time interval.
unit DELAY_DEM_5 = ITEMS

aux DELAY_DEM_6 = DEMAND_1*IF(P_CCR_PROD_START_TIME>7 AND P_CCR_PROD_START_TIME<=8,1,0)

doc DELAY_DEM_6 = This is the DEMAND whose production -in order to be dispatched on time- has P_CCR_PROD_START_TIME more than 7 and less than 8. The production of this demand has to start at the shop's CCR operation (i.e. it has to become part of the rate CCR_PROD_R) at the start of the 7th day after the current time interval. Therefore, it has to be added at the rate P_CCR_PROD_R 6 days after the current time interval.
unit DELAY_DEM_6 = ITEMS

aux DELAY_DEM_7 = DEMAND_1*IF(P_CCR_PROD_START_TIME>8,1,0)
doc DELAY_DEM_7 = This is the DEMAND whose production -in order to be dispatched on time- has P_CCR_PROD_START_TIME more than 8. The production of this demand has to start at the shop's CCR operation (i.e. it has to become part of the rate CCR_PROD_R) at the start of the 8th day after the current time interval. Therefore, it has to be added at the rate P_CCR_PROD_R 7 days after the current time interval.
unit DELAY_DEM_7 = ITEMS

aux DELAY_MAT_3 = MAT_ORDER*IF(MAT_L_TIME=3,1,0)
doc DELAY_MAT_3 = This is the raw material order which fulfillment is planned to be 3 days after its release.
unit DELAY_MAT_3 = Kg

aux DELAY_MAT_4 = MAT_ORDER*IF(MAT_L_TIME>3 AND MAT_L_TIME<=4,1,0)
doc DELAY_MAT_4 = This is the raw material order which fulfillment is planned to be at the 4th day after its release.
unit DELAY_MAT_4 = Kg

aux DELAY_MAT_5 = MAT_ORDER*IF(MAT_L_TIME>4 AND MAT_L_TIME<=5,1,0)
doc DELAY_MAT_5 = This is the raw material order which fulfillment is planned to be at the 5th day after its release.
unit DELAY_MAT_5 = Kg

aux DELAY_MAT_6 = MAT_ORDER*IF(MAT_L_TIME>5,1,0)
doc DELAY_MAT_6 = This is the raw material order which fulfillment is planned to be at the 6th day after its release.
unit DELAY_MAT_6 = Kg

aux DEM_SD = DEM_M/4
doc DEM_SD = This is the standard deviation of the demand for the case of the normally distributed demand. It is set equal to 1/4 of the demand mean (DEM_M).
unit DEM_SD = ITEMS/DAY

aux DEMAND = 1*NORMAL(DEM_M, DEM_SD,0.1)+0*PULSE(1000,400,10000)
+0*(7.5+SINWAVE(1.5,500))
doc DEMAND = This is the current demand of the shop. It follows a normal distribution with mean value and standard deviation equal to DEM_M and

DEM_SD respectively. In case we want to have a demand pulse or a wavy demand we change the required 0 to 1.
unit DEMAND = ITEMS/DAY

aux DEMAND_1 = DEMAND*TIMESTEP
doc DEMAND_1 = This is the demand of the shop at the current time interval.
unit DEMAND_1 = ITEMS

aux DIVERGENCE = ABS(P_DEM_FULF-SHIPMENTS)
doc DIVERGENCE = This is the absolute difference between the planned demand fulfillment and the actual shipments at the current time interval.
unit DIVERGENCE = ITEMS

aux MAT_L_TIME = RANDOM(P_MAT_L_TIME,2*P_MAT_L_TIME,0.2) *MAT_ORDER_SWITCH
doc MAT_L_TIME = This is the real value of the material lead time. It is uniformly distributed between the planned material lead time and the twofold value of it.
unit MAT_L_TIME = DAYS

aux MAT_L_TIME_M = 1.5*P_MAT_L_TIME
doc MAT_L_TIME_M = This is the mean value of the real material lead time for the raw material used.
unit MAT_L_TIME_M = DAYS

aux MAT_ORDER = IF(MAT_ORDER_ROPE>0,IF(MAT_TIME_BUFFER <MIN_P_MAT_TIME_BUFFER,MAT_ORDER_QUANTITY,0),0)
doc MAT_ORDER = This is the raw material quantity we order at the current time interval. Its value is equal to zero whenever the CCR operation of the shop was idle at the time interval four timesteps before the current one. Otherwise, its value is equal to the material order quantity (MAT_ORDER_QUANTITY) whenever the current material time buffer is less than its minimum planned value.
unit MAT_ORDER = Kg

aux MAT_ORDER_QUANTITY = 3*P_MAT_L_TIME*MAT_FACTOR /PROD_DUR_2_M
doc MAT_ORDER_QUANTITY = This is the quantity of the material order batch. It is set equal to 3 times the raw material usage expected during the planned material lead time considering that the CCR machine operates at its capacity; i.e. it is equal to 3 times the material required to fulfill the average material demand of the CCR operation during the planned material lead time (P_MAT_L_TIME).
unit MAT_ORDER_QUANTITY = Kg

aux MAT_ORDER_ROPE = DELAYPPL(PROD_R_2,4*TIMESTEP,0)
doc MAT_ORDER_ROPE = This is the rope of the DBR logic for the raw material procurement process. We set this rope by using the Real Time (RT) methodology, i.e. the raw material inventory is monitored for material order at the rate at which the products are processed by the CCR operation of the shop and with a delay of 4 timesteps in order the size of timestep to fullfil the constraint: dt<=T/2n.

unit MAT_ORDER_ROPE = ITEMS/DAY

aux MAT_ORDER_SWITCH = IF(MAT_ORDER>0,1,0)
doc MAT_ORDER_SWITCH = This is a switch pointing that we order raw material at the current time interval.

aux MAT_PROC_3 = DELAYPPL(DELAY_MAT_3,3,0)
doc MAT_PROC_3 = This is the raw material order quantity which fulfillment is planned to be 3 days after the current interval, in order the material order part named DELAY_MAT_3 to be received on time.
unit MAT_PROC_3 = Kg

aux MAT_PROC_4 = DELAYPPL(DELAY_MAT_4,4,0)
doc MAT_PROC_4 = This is the raw material order quantity which fulfillment is planned to be at the 4th day after the current interval, in order the material order part named DELAY_MAT_4 to be received on time.
unit MAT_PROC_4 = Kg

aux MAT_PROC_5 = DELAYPPL(DELAY_MAT_5,5,0)
doc MAT_PROC_5 = This is the raw material order quantity which fulfillment is planned to be at the 5th day after the current interval, in order the material order part named DELAY_MAT_5 to be received on time.
unit MAT_PROC_5 = Kg

aux MAT_PROC_6 = DELAYPPL(DELAY_MAT_6,6,0)
doc MAT_PROC_6 = This is the raw material order quantity which fulfillment is planned to be at the 6th day after the current interval, in order the material order part named DELAY_MAT_6 to be received on time.
unit MAT_PROC_6 = Kg

aux MAT_TIME_BUFFER = (MATERIAL+MATERIAL_IN_TRANSIT)/MAT_FACTOR*PROD_DUR_2_M
doc MAT_TIME_BUFFER = This is the current material time buffer of the material procurement process; i.e. it is the current material inventory on hand and in transit expressed in time units of the shop's CCR operation. This buffer is continually monitored in order to be more than the minimum planned material time buffer required (MIN_P_MAT_TIME_BUFFER). Whenever MAT_TIME_BUFFER is less than MIN_P_MAT_TIME_BUFFER we order a material order quantity (Q_MAT_QUANTITY).
unit MAT_TIME_BUFFER = DAYS

aux MIN_P_MAT_TIME_BUFFER = CEIL(3*DEM_M*TIMESTEP*MAT_FACTOR/MAT_ORDER_QUANTITY)* MAT_L_TIME_M+3*DEM_M*TIMESTEP*PROD_DUR_1_M
doc MIN_P_MAT_TIME_BUFFER = This is the minimum required material time buffer of the raw material procurement process. It is set equal to 3 times the mean value of duration before the CCR operation (i.e. for procurement of raw material and for production at operation 1) for the mean value of demand during one time

interval. Note that the number of material orders necessary to cover the respective material quantity is set equal to the smallest integer greater than or equal to its original estimated value.
unit MIN_P_MAT_TIME_BUFFER = DAYS

aux MIN_P_PR_TIME_BUFFER = 3*DEM_M*TIMESTEP*PROD_DUR_1_M
doc MIN_P_PR_TIME_BUFFER = This is the minimum planned production time buffer which is required before the CCR operation. It is set equal to 3 times the mean value of production duration before the CCR operation (i.e. for operation 1) for the mean value of Demand during one time interval.
unit MIN_P_PR_TIME_BUFFER = DAYS

aux P_CCR_PR_4 = DELAYPPL(DELAY_DEM_3,3,0)
doc P_CCR_PR_4 = This is the production which is added to the rate P_CCR_PROD_R at the 3rd day after the current interval, in order the demand part named DELAY_DEM_3 to be satisfied on time. Therefore, it is planned to start at the CCR operation of the shop at the start of the 4th day after the current interval.
unit P_CCR_PR_4 = ITEMS

aux P_CCR_PR_5 = DELAYPPL(DELAY_DEM_4,4,0)
doc P_CCR_PR_5 = This is the production which is added to the rate P_CCR_PROD_R at the 4th day after the current interval, in order the demand part named DELAY_DEM_4 to be satisfied on time. Therefore, it is planned to start at the CCR operation of the shop at the start of the 5th day after the current interval.
unit P_CCR_PR_5 = ITEMS

aux P_CCR_PR_6 = DELAYPPL(DELAY_DEM_5,5,0)
doc P_CCR_PR_6 = This is the production which is added to the rate P_CCR_PROD_R at the 5th day after the current interval, in order the demand part named DELAY_DEM_5 to be satisfied on time. Therefore, it is planned to start at the CCR operation of the shop at the start of the 6th day after the current interval.
unit P_CCR_PR_6 = ITEMS

aux P_CCR_PR_7 = DELAYPPL(DELAY_DEM_6,6,0)
doc P_CCR_PR_7 = This is the production which is added to the rate P_CCR_PROD_R at the 6th day after the current interval, in order the demand part named DELAY_DEM_6 to be satisfied on time. Therefore, it is planned to start at the CCR operation of the shop at the start of the 7th day after the current interval.
unit P_CCR_PR_7 = ITEMS

aux P_CCR_PR_8 = DELAYPPL(DELAY_DEM_7,7,0)
doc P_CCR_PR_8 = This is the production which is added to the rate P_CCR_PROD_R at the 7th day after the current interval, in order the demand part named DELAY_DEM_7 to be satisfied on time. Therefore, it is planned to

start at the CCR operation of the shop at the start of the 8th day after the current interval.
unit P_CCR_PR_8 = ITEMS

aux P_CCR_PROD_START_TIME = MAX(0,P_LEAD_TIME-REQ_PROD_DURATION_2_3-MIN_P_PR_TIME_BUFFER)
doc P_CCR_PROD_START_TIME = This is the planned time available for the demand production at the shop's operations before the CCR one, in order the demand production at the CCR stage to start on time, i.e. the demand production is finished up to its planned lead time. The minimum production time buffer is subtracted by this time, in order to anticipate any possible delay to the average time of production duration in operations 2 and 3. If the calculated difference is negative, the demand production at the CCR operation of the shop has to be start immediately, because its fulfillment is expected later than the planned lead time.
unit P_CCR_PROD_START_TIME = DAYS

aux P_DEM_FULF = DELAYPPL(DEMAND_1,P_LEAD_TIME,0)
doc P_DEM_FULF = This is the demand we have to satisfy at the current time interval. It is equal with the demand occured 10 days ago, whereas 10 stands for the duration of the planned lead time (P_LEAD_TIME).
unit P_DEM_FULF = ITEMS

aux PR_TIME_BUFFER = WIP_1*PROD_DUR_2_M
doc PR_TIME_BUFFER = This is the current time buffer before the CCR operation of the shop; i.e. it is the current WIP_1 expressed in time units of the shop's CCR operation. This buffer is continually monitored in order to be more than the minimum planned production time buffer required (MIN_P_PR_TIME_BUFFER). Whenever PR_TIME_BUFFER is less than MIN_P_PR_TIME_BUFFER we produce at the first operation (i.e. before the CCR operation) with the maximum production rate possible considering the availability of raw material.
unit PR_TIME_BUFFER = DAYS

aux PROD_DUR_1 = EXPRND(PROD_DUR_1_M,0.3)
doc PROD_DUR_1 = This is the production duration of the items processed at the gateway operation of the shop (operation 1) at the current time interval. This duration follows an exponential distribution with mean value equal to PROD_DUR_1_M.
unit PROD_DUR_1 = DAYS/ITEM

aux PROD_DUR_2 = EXPRND(PROD_DUR_2_M,0.4)
doc PROD_DUR_2 = This is the production duration of the items processed at the shop's CCR operation (operation 2) at the current time interval. This duration follows an exponential distribution with mean value equal to PROD_DUR_2_M.
unit PROD_DUR_2 = DAYS/ITEM

aux PROD_DUR_3 = EXPRND(PROD_DUR_3_M,0.5)

doc PROD_DUR_3 = This is the production duration of the items processed at the end operation of the shop (operation 3) at the current time interval. This duration follows an exponential distribution with mean value equal to PROD_DUR_3_M.
unit PROD_DUR_3 = DAYS/ITEM

aux PROD_R_ROPE = DELAYPPL(PROD_R_2,4*TIMESTEP,0)
doc PROD_R_ROPE = This is the rope of the DBR logic for the production process. We set this rope by using the Real Time (RT) methodology, i.e. raw material is released into the shop's gateway operation at the rate at which it is processed by the CCR and with a delay of 4 timesteps in order the size of timestep to fulfill the constraint: dt<=T/2n.
unit PROD_R_ROPE = ITEMS/DAY

aux REQ_PROD_DURATION_2_3 = (PROD_DUR_2_M+1/(1/PROD_DUR_3_M-DEM_M))*DEMAND_1
doc REQ_PROD_DURATION_2_3 = This is the mean expected time for the production of the demand of the current time interval from the CCR up to the end operation of the shop.
unit REQ_PROD_DURATION_2_3 = DAYS

aux SHIPMENTS = SHIPMENTS_R*TIMESTEP
doc SHIPMENTS = This is the demand satisfied at the current time interval.
unit SHIPMENTS = ITEMS

const DEM_M = 7.5
doc DEM_M = This is the mean value of the demand for the case of the normally distributed demand.
unit DEM_M = ITEMS/DAY

const MAT_FACTOR = 2
doc MAT_FACTOR = This is the quantity of raw material required for the production of 1 item of the product.
unit MAT_FACTOR = Kg/ITEM

const P_LEAD_TIME = 10
doc P_LEAD_TIME = This is the planned lead time, i.e. it is the duration available for the production of the demand from the time of the demand release up to the time of its planned fulfillment.
unit P_LEAD_TIME = DAYS

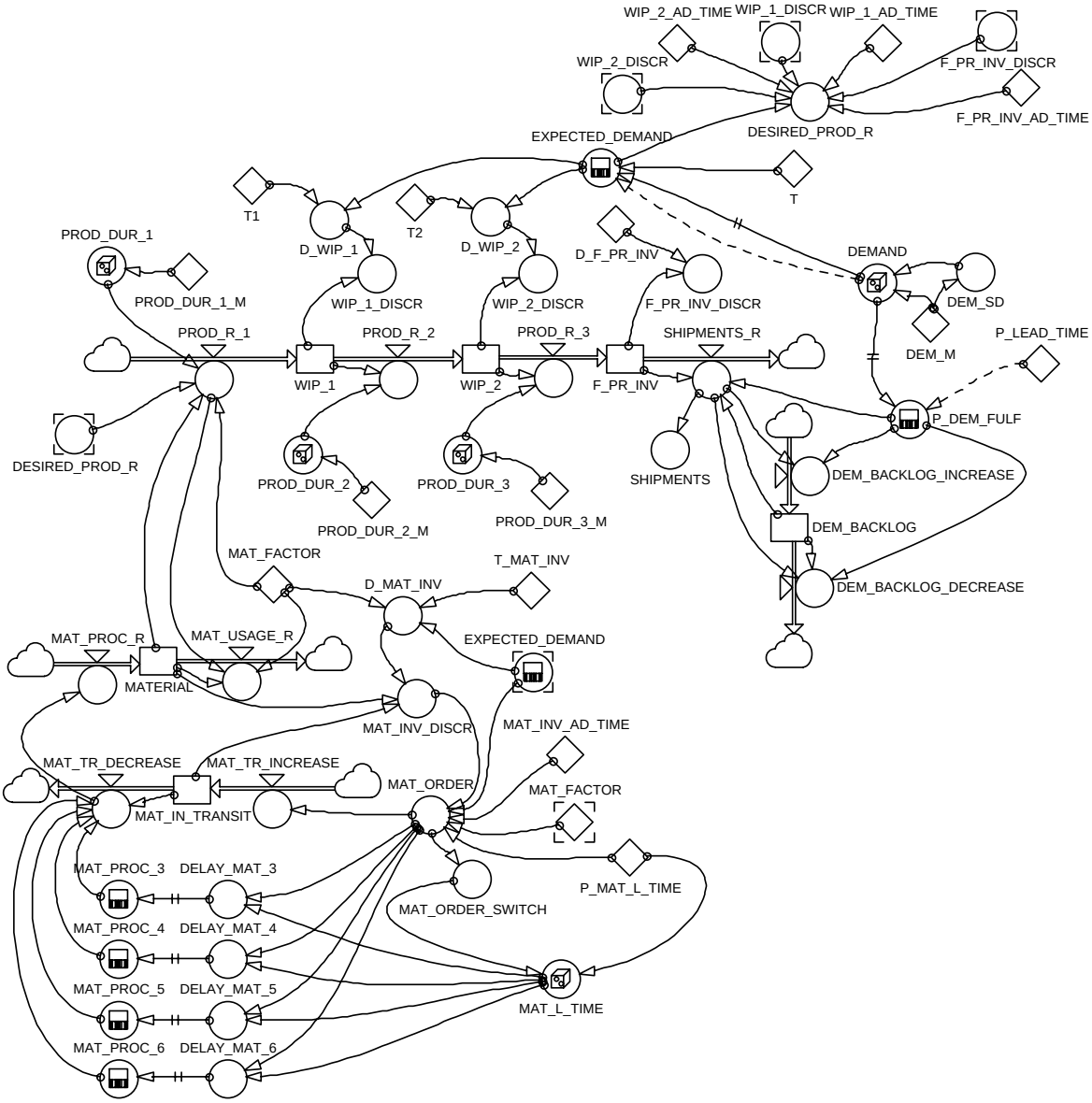
const P_MAT_L_TIME = 3
doc P_MAT_L_TIME = This is the planned material lead time for the raw material, that it is offered by the supplier.
unit P_MAT_L_TIME = DAYS

const PROD_DUR_1_M = 0.0625
doc PROD_DUR_1_M = This is the mean value of the process duration at the gateway operation of the shop (operation 1).

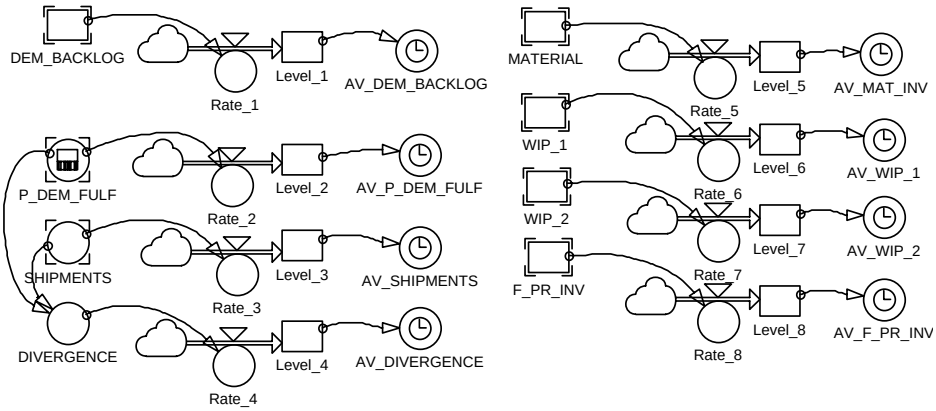
```
unit   PROD_DUR_1_M = DAYS/ITEM

const  PROD_DUR_2_M = 0.125
doc    PROD_DUR_2_M = This is the mean value of the process duration at the shop's
       CCR operation (operation 2).
unit   PROD_DUR_2_M = DAYS/ITEM

const  PROD_DUR_3_M = 0.0625
doc    PROD_DUR_3_M = This is the mean value of the process duration at the end
       operation of the shop (operation 3).
unit   PROD_DUR_3_M = DAYS/ITEM
```

B. AA approach

B.1 Stock-flow Diagram for Scheduling and Production Sector



B.2 Stock-flow Diagram for Controlling Sector



B.3 Equations

init DEM_BACKLOG = 0
flow DEM_BACKLOG = -dt*DEM_BACKLOG_DECREASE
+dt*DEM_BACKLOG_INCREASE
doc DEM_BACKLOG = This is the demand, whose fulfillment is going to be delayed (i.e. it is going to be satisfied more than 10 days after its release).
unit DEM_BACKLOG = ITEMS

init F_PR_INV = 0
flow F_PR_INV = -dt*SHIPMENTS_R+dt*PROD_R_3
doc F_PR_INV = This is the inventory of the finished product, which is available after the end operation of the shop.
unit F_PR_INV = ITEMS

init Level_1 = 0
flow Level_1 = +dt*Rate_1
doc Level_1 = This level is used to calculate the average value of the demand backlog (AV_DEM_BACKLOG).
unit Level_1 = ITEMS*days

init Level_2 = 0
flow Level_2 = +dt*Rate_2
doc Level_2 = This level is used to calculate the average value of the planned demand fulfillment (AV_P_DEM_FULF).
unit Level_2 = ITEMS

init Level_3 = 0
flow Level_3 = +dt*Rate_3
doc Level_3 = This level is used to calculate the average value of the shipments (AV_SHIPMENTS).
unit Level_3 = ITEMS

init Level_4 = 0
flow Level_4 = +dt*Rate_4
doc Level_4 = This level is used to calculate the average value of the divergence (AV_DIVERGENCE).
unit Level_4 = ITEMS

init Level_5 = 0
flow Level_5 = +dt*Rate_5
doc Level_5 = This level is used to calculate the average value of the raw material inventory (AV_MAT_INV).
unit Level_5 = Kg*DAYS

init Level_6 = 0
flow Level_6 = +dt*Rate_6
doc Level_6 = This level is used to calculate the average value of the inventory after the first operation of the flow shop (AV_WIP_1).

unit Level_6 = ITEMS*DAYS

init Level_7 = 0
flow Level_7 = +dt*Rate_7
doc Level_7 = This level is used to calculate the average value of the inventory after the second operation of the flow shop (AV_WIP_2).
unit Level_7 = ITEMS*DAYS

init Level_8 = 0
flow Level_8 = +dt*Rate_8
doc Level_8 = This level is used to calculate the average value of the finished product inventory of the flow shop (AV_F_PR_INV).
unit Level_8 = ITEMS*DAYS

init MAT_IN_TRANSIT = 0
flow MAT_IN_TRANSIT = -dt*MAT_TR_DECREASE+dt*MAT_TR_INCREASE
doc MAT_IN_TRANSIT = This is the current level of material inventory in transit; i.e. the material inventory that has been ordered and it is expected to be delivered at the shop later. Its initial value is set equal to zero.
unit MAT_IN_TRANSIT = Kg

init MATERIAL = 2*144
flow MATERIAL = -dt*MAT_USAGE_R+dt*MAT_PROC_R
doc MATERIAL = This is the current level of raw material inventory on hand.
unit MATERIAL = Kg

init WIP_1 = 0
flow WIP_1 = +dt*PROD_R_1-dt*PROD_R_2
doc WIP_1 = This is the inventory available before the shop's CCR operation.
unit WIP_1 = ITEMS

init WIP_2 = 0
flow WIP_2 = -dt*PROD_R_3+dt*PROD_R_2
doc WIP_2 = This is the inventory available after the shop's CCR operation.
unit WIP_2 = ITEMS

aux DEM_BACKLOG_DECREASE = MIN(MAX(SHIPMENTS_R-P_DEM_FULF/TIMESTEP,0),DEM_BACKLOG/TIMESTEP)
doc DEM_BACKLOG_DECREASE = This is the demand fulfillment with delay at the current time interval; i.e. it is the demand satisfied later than 10 days (LEAD_TIME) after its release.
unit DEM_BACKLOG_DECREASE = ITEMS/DAY

aux DEM_BACKLOG_INCREASE = MAX(P_DEM_FULF/TIMESTEP-SHIPMENTS_R,0)
doc DEM_BACKLOG_INCREASE = This is the invalid demand fulfillment at the current time interval; i.e. it is the demand that although has to be satisfied at the

current time interval (10 days after its release), it is impossible to be satisfied on time.
unit DEM_BACKLOG_INCREASE = ITEMS/DAY

aux MAT_PROC_R = MAT_TR_DECREASE
doc MAT_PROC_R = This is the rate of the raw material procurement received; i.e. the raw material delivery at the current time interval. It is set equal to the material in transit decrease.
unit MAT_PROC_R = kg/DAY

aux MAT_TR_DECREASE = MIN(MAT_PROC_3+MAT_PROC_4+MAT_PROC_5+MAT_PROC_6,MAT_IN_TRANSIT)/TIMESTEP
doc MAT_TR_DECREASE = This is the rate of the raw material received; i.e. the raw material delivery at the current time interval.
unit MAT_TR_DECREASE = kg/DAY

aux MAT_TR_INCREASE = MAT_ORDER/TIMESTEP
doc MAT_TR_INCREASE = This is the raw material quantity ordered at the current time interval.
unit MAT_TR_INCREASE = kg/DAY

aux MAT_USAGE_R = MIN(PROD_R_1*MAT_FACTOR, MATERIAL/TIMESTEP)
doc MAT_USAGE_R = This is the rate of the raw material usage by the production at the gateway operation of the shop (PROD_R_1).
unit MAT_USAGE_R = kg/DAY

aux PROD_R_1 = MIN(DESIRED_PROD_R,1/PROD_DUR_1, MATERIAL/MAT_FACTOR/TIMESTEP)
doc PROD_R_1 = This is what we produce at the gateway operation of the shop according to the AA approach.
unit PROD_R_1 = ITEMS/DAY

aux PROD_R_2 = MIN(1/PROD_DUR_2,WIP_1/TIMESTEP)
doc PROD_R_2 = This is what we produce at the shop's CCR operation.
unit PROD_R_2 = ITEMS/DAY

aux PROD_R_3 = MIN(1/PROD_DUR_3,WIP_2/TIMESTEP)
doc PROD_R_3 = This is what we produce at the third operation of the shop.
unit PROD_R_3 = ITEMS/DAY

aux Rate_1 = DEM_BACKLOG
doc Rate_1 = This rate is used to calculate the average value of the demand backlog (AV_DEM_BACKLOG).
unit Rate_1 = ITEMS

aux Rate_2 = P_DEM_FULF/TIMESTEP

doc Rate_2 = This rate is used to calculate the average value of the planned demand fulfillment (AV_P_DEM_FULF).
unit Rate_2 = ITEMS/DAY

aux Rate_3 = SHIPMENTS/TIMESTEP
doc Rate_3 = This rate is used to calculate the average value of the shipments (AV_SHIPMENTS).
unit Rate_3 = ITEMS/DAY

aux Rate_4 = DIVERGENCE/TIMESTEP
doc Rate_4 = This rate is used to calculate the average value of the divergence (AV_DIVERGENCE).
unit Rate_4 = ITEMS/DAY

aux Rate_5 = MATERIAL
doc Rate_5 = This rate is used to calculate the average value of the raw material inventory (AV_MAT_INV).
unit Rate_5 = Kg

aux Rate_6 = WIP_1
doc Rate_6 = This rate is used to calculate the average value of the inventory after the first operation of the flow shop (AV_WIP_1).
unit Rate_6 = ITEMS

aux Rate_7 = WIP_2
doc Rate_7 = This rate is used to calculate the average value of the inventory after the second operation of the flow shop (AV_WIP_2).
unit Rate_7 = ITEMS

aux Rate_8 = F_PR_INV
doc Rate_8 = This rate is used to calculate the average value of the finished product inventory of the flow shop (AV_F_PR_INV).
unit Rate_8 = ITEMS

aux SHIPMENTS_R = MIN(P_DEM_FULF+DEM_BACKLOG,F_PR_INV) /TIMESTEP
doc SHIPMENTS_R = This is the rate of demand shipments.
unit SHIPMENTS_R = ITEMS/DAY

aux AV_DEM_BACKLOG = Level_1 DIVZ0 TIME
doc AV_DEM_BACKLOG = This is the average value of the demand backlog (DEM_BACKLOG) from the simulation start up to the current time interval.
unit AV_DEM_BACKLOG = ITEMS

aux AV_DIVERGENCE = Level_4 DIVZ0 TIME
doc AV_DIVERGENCE = This is the average value of the DIVERGENCE from the simulation start up to the current time interval.
unit AV_DIVERGENCE = ITEMS/DAY

aux AV_F_PR_INV = Level_8 DIVZ0 TIME

doc AV_F_PR_INV = This is the average value of the finished product inventory (F_PR_INV) from the simulation start up to the current time interval.
unit AV_F_PR_INV = ITEMS

aux AV_MAT_INV = Level_5 DIVZ0 TIME
doc AV_MAT_INV = This is the average value of the raw material inventory on hand (MAT_INV) from the simulation start up to the current time interval.
unit AV_MAT_INV = Kg

aux AV_P_DEM_FULF = Level_2 DIVZ0 TIME
doc AV_P_DEM_FULF = This is the average value of the planned demand fulfillment (P_DEM_FULF) from the simulation start up to the current time interval.
unit AV_P_DEM_FULF = ITEMS/DAY

aux AV_SHIPMENTS = Level_3 DIVZ0 TIME
doc AV_SHIPMENTS = This is the average value of the SHIPMENTS from the simulation start up to the current time interval.
unit AV_SHIPMENTS = ITEMS/DAY

aux AV_WIP_1 = Level_6 DIVZ0 TIME
doc AV_WIP_1 = This is the average value of the inventory after the first operation of the shop (WIP_1) from the simulation start up to the current time interval.
unit AV_WIP_1 = ITEMS

aux AV_WIP_2 = Level_7 DIVZ0 TIME
doc AV_WIP_2 = This is the average value of the inventory after the second operation of the shop (WIP_2) from the simulation start up to the current time interval.
unit AV_WIP_2 = ITEMS

aux D_MAT_INV = T_MAT_INV*EXPECTED_DEMAND*MAT_FACTOR
doc D_MAT_INV = This is the desired raw material inventory according to the AA approach.
unit D_MAT_INV = Kg

aux D_WIP_1 = T1*EXPECTED_DEMAND
doc D_WIP_1 = This is the desired inventory after the first operation of the shop according to the AA approach.
unit D_WIP_1 = ITEMS

aux D_WIP_2 = T2*EXPECTED_DEMAND
doc D_WIP_2 = This is the desired inventory after the second operation of the shop according to the AA approach.
unit D_WIP_2 = ITEMS

aux DELAY_MAT_3 = MAT_ORDER*IF(MAT_L_TIME=3,1,0)

doc DELAY_MAT_3 = This is the raw material order which delivery is planned to be 3 days after its release.
unit DELAY_MAT_3 = Kg

aux DELAY_MAT_4 = MAT_ORDER*IF(MAT_L_TIME>3 AND MAT_L_TIME<=4,1,0)
doc DELAY_MAT_4 = This is the raw material order which delivery is planned to be at the 4th day after its release.
unit DELAY_MAT_4 = Kg

aux DELAY_MAT_5 = MAT_ORDER*IF(MAT_L_TIME>4 AND MAT_L_TIME<=5,1,0)
doc DELAY_MAT_5 = This is the raw material order which delivery is planned to be at the 5th day after its release.
unit DELAY_MAT_5 = Kg

aux DELAY_MAT_6 = MAT_ORDER*IF(MAT_L_TIME>5,1,0)
doc DELAY_MAT_6 = This is the raw material order which delivery is planned to be at the 6th day after its release.
unit DELAY_MAT_6 = Kg

aux DEM_SD = DEM_M/4
doc DEM_SD = This is the standard deviation of the demand for the case of the normally distributed demand. It is set equal to 1/4 of the demand mean (DEM_M).
unit DEM_SD = ITEMS/DAY

aux DEMAND = 1*NORMAL(DEM_M,DEM_SD,0.1)+0*PULSE(1000,400,10000) +0*(7.5+SINWAVE(1.5,500))
doc DEMAND = This is the current demand of the shop. It follows a normal distribution with mean value and standard deviation equal to DEM_M and DEM_SD respectively. In case we want to have a demand pulse or a wavy demand we change the required 0 to 1.
unit DEMAND = ITEMS/DAY

aux DESIRED_PROD_R = MAX(0,EXPECTED_DEMAND +F_PR_INV_DISCR/F_PR_INV_AD_TIME+WIP_2_DISCR/WIP_2_AD_TIME +WIP_1_DISCR/WIP_1_AD_TIME)
doc DESIRED_PROD_R = This is the desired production rate of the first operation of the shop according to the AA approach.
unit DESIRED_PROD_R = ITEMS/DAY

aux DIVERGENCE = ABS(P_DEM_FULF-SHIPMENTS)
doc DIVERGENCE = This is the absolute difference between the planned demand fulfillment and the actual shipments at the current time interval.
unit DIVERGENCE = ITEMS/DAY

aux EXPECTED_DEMAND = DELAYINF(DEMAND,T,1,DEMAND)

doc EXPECTED_DEMAND = This is the demand expected to occur at the current day of simulation according to the AA approach.
unit EXPECTED_DEMAND = ITEMS/DAY

aux F_PR_INV_DISCR = D_F_PR_INV-F_PR_INV
doc F_PR_INV_DISCR = This is the discrepancy occured at the current time interval between the desired finished product inventory and its real value.
unit F_PR_INV_DISCR = ITEMS

aux MAT_INV_DISCR = D_MAT_INV-MATERIAL-MAT_IN_TRANSIT
doc MAT_INV_DISCR = This is the discrepancy occured at the current time interval between the desired raw material inventory and its real value.
unit MAT_INV_DISCR = Kg

aux MAT_L_TIME = RANDOM(P_MAT_L_TIME,2*P_MAT_L_TIME,0.2) *MAT_ORDER_SWITCH
doc MAT_L_TIME = This is the real value of the raw material lead time. It is uniformly distributed between the planned material lead time and the twofold value of it.
unit MAT_L_TIME = DAYS

aux MAT_ORDER = MAX(0,MAT_INV_DISCR/MAT_INV_AD_TIME *TIMESTEP+EXPECTED_DEMAND*P_MAT_L_TIME*MAT_FACTOR)
doc MAT_ORDER = This is the raw material quantity we order at the current time interval according to the AA approach.
unit MAT_ORDER = Kg

aux MAT_ORDER_SWITCH = IF(MAT_ORDER>0,1,0)
doc MAT_ORDER_SWITCH = This is a switch pointing that we order raw material at the current time interval.

aux MAT_PROC_3 = DELAYPPL(DELAY_MAT_3,3,0)
doc MAT_PROC_3 = This is the raw material order quantity which delivery is planned to be 3 days after the current interval, in order the material order part named DELAY_MAT_3 to be received on time.
unit MAT_PROC_3 = Kg

aux MAT_PROC_4 = DELAYPPL(DELAY_MAT_4,4,0)
doc MAT_PROC_4 = This is the raw material order quantity which delivery is planned to be at the 4th day after the current interval, in order the material order part named DELAY_MAT_4 to be received on time.
unit MAT_PROC_4 = Kg

aux MAT_PROC_5 = DELAYPPL(DELAY_MAT_5,5,0)
doc MAT_PROC_5 = This is the raw material order quantity which delivery is planned to be at the 5th day after the current interval, in order the material order part named DELAY_MAT_5 to be received on time.
unit MAT_PROC_5 = Kg

aux MAT_PROC_6 = DELAYPPL(DELAY_MAT_6,6,0)
doc MAT_PROC_6 = This is the raw material order quantity which delivery is planned to be at the 6th day after the current interval, in order the material order part named DELAY_MAT_6 to be received on time.
unit MAT_PROC_6 = Kg

aux P_DEM_FULF = DELAYPPL(DEMAND,P_LEAD_TIME,0)*TIMESTEP
doc P_DEM_FULF = This is the demand we have to satisfy at the current time interval. It is equal with the demand occured 10 days ago, whereas 10 stands for the duration of the planned lead time (P_LEAD_TIME).
unit P_DEM_FULF = ITEMS

aux PROD_DUR_1 = EXPRND(PROD_DUR_1_M,0.3)
doc PROD_DUR_1 = This is the production duration of the items processed at the gateway operation of the shop (operation 1) at the current time interval. This duration follows an exponential distribution with mean value equal to PROD_DUR_1_M.
unit PROD_DUR_1 = DAYS/ITEM

aux PROD_DUR_2 = EXPRND(PROD_DUR_2_M,0.4)
doc PROD_DUR_2 = This is the production duration of the items processed at the CCR operation of the shop (operation 2) at the current time interval. This duration follows an exponential distribution with mean value equal to PROD_DUR_2_M.
unit PROD_DUR_2 = DAYS/ITEM

aux PROD_DUR_3 = EXPRND(PROD_DUR_3_M,0.5)
doc PROD_DUR_3 = This is the production duration of the items processed at the end operation of the shop (operation 3) at the current time interval. This duration follows an exponential distribution with mean value equal to PROD_DUR_3_M.
unit PROD_DUR_3 = DAYS/ITEM

aux SHIPMENTS = SHIPMENTS_R*TIMESTEP
doc SHIPMENTS = This is the demand we satisfy at the current time interval.
unit SHIPMENTS = ITEMS

aux WIP_1_DISCR = D_WIP_1-WIP_1
doc WIP_1_DISCR = This is the discrepancy occured at the current time interval between the desired inventory after the operation 1 of the shop and its real value.
unit WIP_1_DISCR = ITEMS

aux WIP_2_DISCR = D_WIP_2-WIP_2
doc WIP_2_DISCR = This is the discrepancy occured at the current time interval between the desired inventory after the shop's CCR operation (operation 2) and its real value.
unit WIP_2_DISCR = ITEMS

const D_F_PR_INV = 0

doc D_F_PR_INV = This is the desired finished product inventory of the shop according to the AA approach.
unit D_F_PR_INV = ITEMS

const DEM_M = 7.5
doc DEM_M = This is the mean value of the demand for the case of the normally distributed demand.
unit DEM_M = ITEMS/DAY

const F_PR_INV_AD_TIME = 2
doc F_PR_INV_AD_TIME = This is the adjustment time for the finished products inventory according to the AA approach. In case of scenario A it is set equal to 5, whereas in case of scenario B it is equal to 2.
unit F_PR_INV_AD_TIME = DAYS

const MAT_FACTOR = 2
doc MAT_FACTOR = This is the quantity of raw material required for the production of 1 item of the product.
unit MAT_FACTOR = Kg/ITEM

const MAT_INV_AD_TIME = 2
doc MAT_INV_AD_TIME = This is the adjustment time for the raw material inventory according to the AA approach. In case of scenario A it is set equal to 5, whereas in case of scenario B it is equal to 2.
unit MAT_INV_AD_TIME = DAYS

const P_LEAD_TIME = 10
doc P_LEAD_TIME = This is the planned lead time, i.e. it is the duration available for the production of the demand from the time of the demand release up to the time of its planned fulfillment.
unit P_LEAD_TIME = DAYS

const P_MAT_L_TIME = 3
doc P_MAT_L_TIME = This is the planned materials delivery lead time for the raw material, that it is offered by the supplier.
unit P_MAT_L_TIME = DAYS

const PROD_DUR_1_M = 0.0625
doc PROD_DUR_1_M = This is the mean value of the process duration at the gateway operation of the shop (operation 1).
unit PROD_DUR_1_M = DAYS/ITEM

const PROD_DUR_2_M = 0.125
doc PROD_DUR_2_M = This is the mean value of the process duration at the shop's CCR operation (operation 2).
unit PROD_DUR_2_M = DAYS/ITEM

const PROD_DUR_3_M = 0.0625

doc PROD_DUR_3_M = This is the mean value of the process duration at the end operation of the shop (operation 3).
unit PROD_DUR_3_M = DAYS/ITEM

const T = 1
doc T = This is the time parameter used to calculate the expected demand according to the AA approach. In the case of the normally distributed demand it is equal to 23 days and in the case of the wavy demand it is equal to 1 day.
unit T = DAYS

const T_MAT_INV = 5
doc T_MAT_INV = This is the time parameter used to estimate the desired raw material inventory according to the AA approach. In case of scenario A it is set equal to 2, whereas in case of scenario B it is equal to 5.
unit T_MAT_INV = DAYS

const T1 = 5
doc T1 = This is the time parameter used to estimate the desired inventory after the first operation of the shop according to the AA approach. In case of scenario A it is set equal to 2, whereas in case of scenario B it is equal to 5.
unit T1 = DAYS

const T2 = 5
doc T2 = This is the time parameter used to estimate the desired inventory after the second operation of the shop according to the AA approach. In case of scenario A it is set equal to 2, whereas in case of scenario B it is equal to 5.
unit T2 = DAYS

const WIP_1_AD_TIME = 2
doc WIP_1_AD_TIME = This is the adjustment time for the inventory after the first operation of the shop according to the AA approach. In case of scenario A it is set equal to 5, whereas in case of scenario B it is equal to 2.
unit WIP_1_AD_TIME = DAYS

const WIP_2_AD_TIME = 2
doc WIP_2_AD_TIME = This is the adjustment time for the inventory after the second operation of the shop according to the AA approach. In case of scenario A it is set equal to 5, whereas in case of scenario B it is equal to 2.
unit WIP_2_AD_TIME = DAYS