Symbols

Sets

Name	Domains	Description
i, i1	*	index
j	i	a duplicate of i
m	*	QC index
n	m	A duplicate of j
L	m, i	
D	m, i	Unloading Containers. U is a subset of index i
C	m, i	All Containers
li	*	AGV index
a, a1, a2, a2_1, a1_1	*	AGV actions
XR, XR1	*	Vertical Operational Area
YR	*	Horizontal Operational Area
YS	YR	Horizontal Seaside Operation Area
YL	YR	Horizontal Path
o	m, i, XR	
A_L_set	XR	
A_R_set	XR	
WT	m, i, a	set of total actions without virtual node. More precisely, just WHWV
WV	m, i, a	Vertical Actions
WH	m, i, a	Horizontal Actions
psi_1	m, i, m, i	sequence of Container jobs for QC
psi_2	m, i, m, i	sequence of Container jobs for ASC
h	m	
k	i	
x_t	XR	
SameAs	*, *	Set Element Comparison Without Checking

Parameters

Name	Domains	Description
S_Q		switch time for qc between two containers
v		AGV speed
Mnum		a very large number
o1	m, i	merely a copy of the o(m,i,XR), with XR treated as a number
G_Q	m, i	
G_Y	m, i	

Variables

Name	Domains	Description
z	m, i, m, i, li	used mainly for handling QC double cycling, it consists of 0 virtual point!
U_AGV	m, i, a, m, i, a	U_AGV(j_1,j_2) conducted before
U_QC	m, i, m, i, a	U_QC(j,WT) conducted before
P_X	m, i, a, XR	P_X(WV,x) finish V loc, These are defined on actions, NOT ON CONTAINERS!
P_Y	m, i, a, YR	P_Y(WH,y) finish H loc, These are defined on actions, NOT ON CONTAINERS!
T_Q	m, i	start time of QC
T_Y	m, i	Start time of agv putting cont on ASC
T_start	m, i, a	Start of agv for action (m,i,a)
t_AGV	m, i, a, m, i, a	t_AGV(WT_1,WT_2
X_position	m, i, a	X_position(WT)
Y_position	m, i, a	Y_position(WT)
obj		objective function

Equations

Name	Domains	Description
ADRP1		AGV Dispatching and Routing Problem
ADRP2		AGV Dispatching and Routing Problem
cnstr_2	m, i	
cnstr_3	m, i, li	C,B
cnstr_4	li	B with 0 virtual node
cnstr_5	li	"B with 0 virutal node"
cnstr_6	m, i	L
cnstr_7	m, i	D
cnstr_8	m, i, n, j, XR	C,C,XR
cnstr_9	m, i, n, j, YR	C,C,YR
cnstr_10	m, i, a	C,a
cnstr_11	m, i, a	C,a
cnstr_12	m, i	L
cnstr_13	m, i	D
cnstr_14	m, i, XR	D
cnstr_15	m, i	L
cnstr_16	m, i	D
cnstr_17	m, i	L
cnstr_18	m, i, XR	L
cnstr_19	m, i	D
cnstr_20	m, i, a, a, YR	WH,YR
cnstr_21	m, i, a, a, XR	WV,XR
cnstr_22	m, i, n, j	C,C
cnstr_23	m, i, a, n, j, a, YR, XR, a, a	WH,WH,YR,XR
cnstr_24	m, i, n, j, a	C, WH
cnstr_25	m, i, n, j, a, a	C, WH

Name	Domains	Description
cnstr_26_1	n, j, a, YS, m, i, a, a	WH,YS,D
cnstr_26_2	n, j, a, YS, m, i, a, a	WH,YS,D
cnstr_27	m, i, a, n, j, a, XR	WV, XR
cnstr_28	m, i, a, a	C,a
cnstr_29	m, i, i	C,C
cnstr_30	m, i, m, i	psi_1
cnstr_31	m, i, m, i	psi_2
cnstr_32	m, i	D
cnstr_33	m, i	L
cnstr_34	m, i, m, i	D,L
cnstr_35	m, i, m, i	L,D
cnstr_36	m, i, a	D,a
cnstr_37	m, i, a	D,a
cnstr_38	m, i, a, a, n, j, a	WT,WT
cnstr_39	m, i, a, XR	C,a,XR
cnstr_40	m, i, a, YR	C,a,YR
cnstr_41_1	m, i, a, m, i, a	
cnstr_41_2	m, i, a, m, i, a	
cnstr_41_3	m, i, a, m, i, a	
cnstr_41_4	m, i, a, m, i, a	

Equation Definitions

ADRP1

$$\text{obj} \geq \text{T\_Q}_{\texttt{m3,i3}} + \text{G\_Q}_{\texttt{m3,i3}}$$

ADRP2

$$\text{obj} \geq \text{T\_Y}_{\texttt{m3,i3}} + \text{G\_Y}_{\texttt{m3,i3}}$$

$\textbf{cnstr\_2}_{m,i}$

$$\sum_{li,n,j|(\text{C}_{n,j} \vee (n=\texttt{m0}) \wedge (j=\texttt{i0}))} \text{z}_{m,i,n,j,li} = 1 \qquad \forall m,i \mid \text{C}_{m,i}$$

$\textbf{cnstr\_3}_{m,i,li}$

$$\sum_{n,j|(\text{C}_{n,j} \vee (n=\texttt{m0}) \wedge (j=\texttt{i0}))} \text{z}_{n,j,m,i,li} = \sum_{h,k|(\text{C}_{h,k} \vee (h=\texttt{m0}) \wedge (k=\texttt{i0}))} \text{z}_{m,i,h,k,li} \qquad \forall m,i,li \mid \text{C}_{m,i}$$

$\textbf{cnstr\_4}_{li}$

$$\sum_{m,i|\text{C}_{m,i}} \text{z}_{\texttt{m0,i0},m,i,li} = 1 \qquad \forall li$$

---

cnstr_5$_{li}$

$$\sum_{m,i|\mathrm{C}_{m,i}} \mathrm{z}_{m,i,\mathtt{m0},\mathtt{i0},li} = 1 \qquad \forall li$$

---

cnstr_6$_{m,i}$

$$\sum_{li,n,j|(\mathrm{D}_{n,j} \vee (n{=}\mathtt{m0}) \wedge (j{=}\mathtt{i0}))} \mathrm{z}_{m,i,n,j,li} = 1 \qquad \forall m,i \mid \mathrm{L}_{m,i}$$

---

cnstr_7$_{m,i}$

$$\sum_{li,n,j|(\mathrm{L}_{n,j} \vee (n{=}\mathtt{m0}) \wedge (j{=}\mathtt{i0}))} \mathrm{z}_{m,i,n,j,li} = 1 \qquad \forall m,i \mid \mathrm{D}_{m,i}$$

---

cnstr_8$_{m,i,n,j,XR}$

$$\mathrm{P\_X}_{m,i,\mathtt{a4},XR} = \mathrm{P\_X}_{n,j,\mathtt{a0},XR}[(\sum_{li} \mathrm{z.L}_{m,i,n,j,li} = 1)] \qquad \forall m,i,n,j,XR \mid (\mathrm{WT}_{m,i,\mathtt{a4}} \wedge \mathrm{WH}_{n,j,\mathtt{a0}})$$

---

cnstr_9$_{m,i,n,j,YR}$

$$\mathrm{P\_Y}_{m,i,\mathtt{a4},YR} = \mathrm{P\_Y}_{n,j,\mathtt{a0},YR}[(\sum_{li} \mathrm{z.L}_{m,i,n,j,li} = 1)] \qquad \forall m,i,n,j,YR \mid (\mathrm{WT}_{m,i,\mathtt{a4}} \wedge \mathrm{WT}_{n,j,\mathtt{a0}})$$

---

cnstr_10$_{m,i,a}$

$$\sum_{XR} \mathrm{P\_X}_{m,i,a,XR} = 1 \qquad \forall m,i,a \mid \mathrm{WT}_{m,i,a}$$

---

cnstr_11$_{m,i,a}$

$$\sum_{YR} \mathrm{P\_Y}_{m,i,a,YR} = 1 \qquad \forall m,i,a \mid \mathrm{WT}_{m,i,a}$$

---

cnstr_12$_{m,i}$

$$\sum_{YL} \mathrm{P\_Y}_{m,i,\mathtt{a0},YL} = 1 \qquad \forall m,i \mid (\mathrm{L}_{m,i} \wedge \mathrm{WT}_{m,i,\mathtt{a0}})$$

---

cnstr_13$_{m,i}$

$$\sum_{YS} \mathrm{P\_Y}_{m,i,\mathtt{a0},YS} = 1 \qquad \forall m,i \mid (\mathrm{D}_{m,i} \wedge \mathrm{WT}_{m,i,\mathtt{a0}})$$

---

cnstr_14$_{m,i,XR}$

$$\mathrm{P\_X}_{m,i,\mathtt{a0},XR} = 1 \qquad \forall m,i,XR \mid (\mathrm{D}_{m,i} \wedge \mathrm{o}_{m,i,XR} \wedge \mathrm{WT}_{m,i,\mathtt{a0}})$$

---

cnstr_15$_{m,i}$

$$\sum_{A\_L\_set, A\_R\_set} \Big(\sum_{x\_t \mid ((\text{x\_t.val} \geq \text{A\_L\_set.val}) \wedge (\text{x\_t.val} \leq \text{A\_R\_set.val}))} \text{P\_X}_{m,i,\texttt{a0},x\_t} \Big) = 1 \qquad \forall m, i \mid (\text{L}_{m,i} \wedge \text{WT}_{m,i,\texttt{a0}})$$

---

cnstr_19$_{m,i}$

$$\sum_{A\_L\_set, A\_R\_set} \Big(\sum_{x\_t \mid ((\text{x\_t.val} \geq \text{A\_L\_set.val}) \wedge (\text{x\_t.val} \leq \text{A\_R\_set.val}))} \text{P\_X}_{m,i,\texttt{a3},x\_t} \Big) = 1 \qquad \forall m, i \mid (\text{D}_{m,i} \wedge \text{WT}_{m,i,\texttt{a3}})$$

---

cnstr_16$_{m,i}$

$$\sum_{YL} \text{P\_Y}_{m,i,\texttt{a3},YL} = 1 \qquad \forall m, i \mid (\text{D}_{m,i} \wedge \text{WT}_{m,i,\texttt{a3}})$$

---

cnstr_17$_{m,i}$

$$\sum_{YS} \text{P\_Y}_{m,i,\texttt{a3},YS} = 1 \qquad \forall m, i \mid (\text{L}_{m,i} \wedge \text{WT}_{m,i,\texttt{a3}})$$

---

cnstr_18$_{m,i,XR}$

$$\text{P\_X}_{m,i,\texttt{a3},XR} = 1 \qquad \forall m, i, XR \mid (\text{L}_{m,i} \wedge \text{o}_{m,i,XR} \wedge \text{WT}_{m,i,\texttt{a3}})$$

---

cnstr_20$_{m,i,a1,a1\_1,YR}$

$$\text{P\_Y}_{m,i,a1,YR} = \text{P\_Y}_{m,i,a1\_1,YR} \qquad \forall m, i, a1, a1\_1, YR \mid (\text{WH}_{m,i,a1} \wedge \text{WT}_{m,i,a1\_1} \wedge (\text{ord}(\text{a1\_1}) = (\text{ord}(\text{a1}) - 1)))$$

---

cnstr_21$_{m,i,a1,a1\_1,XR}$

$$\text{P\_X}_{m,i,a1,XR} = \text{P\_X}_{m,i,a1\_1,XR} \qquad \forall m, i, a1, a1\_1, XR \mid (\text{WH}_{m,i,a1} \wedge \text{WT}_{m,i,a1\_1} \wedge (\text{ord}(\text{a1\_1}) = (\text{ord}(\text{a1}) - 1)))$$

---

cnstr_22$_{m,i,n,j}$

$$\text{U\_AGV}_{m,i,\texttt{a4},n,j,\texttt{a1}} \geq \sum_{li} \text{z}_{m,i,n,j,li} \qquad \forall m, i, n, j \mid (\text{WT}_{m,i,\texttt{a4}} \wedge \text{WT}_{n,j,\texttt{a1}})$$

---

cnstr_23$_{m,i,a1,n,j,a2,YR,XR,a1\_1,a2\_1}$

$$\text{U\_AGV}_{m,i,a1,n,j,a2} + \text{U\_AGV}_{n,j,a2,m,i,a1} + 3 - \text{P\_Y}_{m,i,a1,YR} - \text{P\_Y}_{n,j,a2,YR} - \sum_{XR1 \mid (\text{XR1.val} \leq \text{XR.val})} (\text{P\_X}_{m,i,a1\_1,XR1} + \text{P\_X}_{n,j,a2,XR1} - \text{P\_X}_{m,i,a1,XR1} - \text{P\_X}_{n,j,a2\_1,XR1}) \geq 0 \; \forall m, i, a1, n, j, a2, YR, XR, a1\_1, a2\_1 \mid ((\text{ord}(\text{a1\_1}) = (\text{ord}(\text{a1}) - 1)) \wedge (\text{ord}(\text{a2\_1}) = (\text{ord}(\text{a2}) - 1)) \wedge \text{WH}_{m,i,a1} \wedge \text{WH}_{n,j,a2})$$

---

cnstr_24$_{m,i,n,j,a}$

$\mathrm{T\_Q}_{m,i} + \mathrm{G\_Q}_{m,i} + \mathrm{Mnum} \cdot (1 - \mathrm{U\_QC}_{m,i,n,j,a}) \geq \mathrm{T\_start}_{n,j,a}$ $\forall m, i, n, j, a \mid (\mathrm{C}_{m,i} \wedge \mathrm{WH}_{n,j,a})$

---

cnstr_25$_{m,i,n,j,a1,a1\_1}$

$\mathrm{T\_start}_{n,j,a1} + \mathrm{t\_AGV}_{n,j,a1\_1,n,j,a1} + \mathrm{Mnum} \cdot (1 - \mathrm{U\_QC}_{m,i,n,j,a1}) \geq \mathrm{T\_Q}_{m,i}$ $\forall m, i, n, j, a1, a1\_1 \mid (\mathrm{C}_{m,i} \wedge \mathrm{WH}_{n,j,a1} \wedge (\mathrm{ord(a1\_1)} = (\mathrm{ord(a1)} - 1)))$

---

cnstr_26_1$_{n,j,a2,YS,m,i,a1,a2\_1}$

$(3 - \mathrm{U\_QC}_{m,i,n,j,a2} - \mathrm{P\_Y}_{m,i,a1,YS} - \mathrm{P\_Y}_{n,j,a2,YS} + (\sum_{XR \mid (\mathrm{XR.val} \leq \mathrm{o1}_{m,i})} \mathrm{P\_X}_{n,j,a2,XR} - \sum_{XR \mid (\mathrm{XR.val} > \mathrm{o1}_{m,i})} \mathrm{P\_X}_{n,j,a2\_1,XR}[(X$

$\sum_{XR \mid (\mathrm{XR.val} > \mathrm{o1}_{m,i})} \mathrm{P\_X.L}_{n,j,a2\_1,XR})])) \cdot \mathrm{Mnum} + \mathrm{T\_start}_{n,j,a2} + \mathrm{t\_AGV}_{n,j,a2\_1,m,i,a1} \geq \mathrm{T\_Q}_{m,i} + \mathrm{G\_Q}_{m,i}$ $\forall n, j, a2, YS, m, i, a1, a2\_1 \mid (((a1 = \mathtt{a0}) \wedge \mathrm{D}_{m,i} \vee (a1 = \mathtt{a3}) \wedge \mathrm{L}_{m,i}) \wedge \mathrm{WH}_{n,j,a2} \wedge (\mathrm{ord(a2\_1)} = (\mathrm{ord(a2)} - 1)))$

---

cnstr_26_2$_{n,j,a2,YS,m,i,a1,a2\_1}$

$(3 - \mathrm{U\_QC}_{m,i,n,j,a2} - \mathrm{P\_Y}_{m,i,a1,YS} - \mathrm{P\_Y}_{n,j,a2,YS} + (- \sum_{XR \mid (\mathrm{XR.val} \leq \mathrm{o1}_{m,i})} \mathrm{P\_X}_{n,j,a2,XR} + \sum_{XR \mid (\mathrm{XR.val} > \mathrm{o1}_{m,i})} \mathrm{P\_X}_{n,j,a2\_1,XR}[$

$\sum_{XR \mid (\mathrm{XR.val} > \mathrm{o1}_{m,i})} \mathrm{P\_X.L}_{n,j,a2\_1,XR})])) \cdot \mathrm{Mnum} + \mathrm{T\_start}_{n,j,a2} + \mathrm{t\_AGV}_{n,j,a2\_1,m,i,a1} \geq \mathrm{T\_Q}_{m,i} + \mathrm{G\_Q}_{m,i}$ $\forall n, j, a2, YS, m, i, a1, a2\_1 \mid (((a1 = \mathtt{a0}) \wedge \mathrm{D}_{m,i} \vee (a1 = \mathtt{a3}) \wedge \mathrm{L}_{m,i}) \wedge \mathrm{WH}_{n,j,a2} \wedge (\mathrm{ord(a2\_1)} = (\mathrm{ord(a2)} - 1)))$

---

cnstr_27$_{m,i,a1,n,j,a2,XR}$

$\mathrm{U\_AGV}_{m,i,a1,n,j,a2} + \mathrm{U\_AGV}_{n,j,a2,m,i,a1} \geq \mathrm{P\_X}_{m,i,a1,XR} + \mathrm{P\_X}_{n,j,a2,XR} - 1$ $\forall m, i, a1, n, j, a2, XR \mid (\mathrm{WV}_{m,i,a1} \wedge \mathrm{WV}_{n,j,a2})$

---

cnstr_28$_{m,i,a1,a1\_1}$

$\mathrm{U\_AGV}_{m,i,a1\_1,m,i,a1} = 1$ $\forall m, i, a1, a1\_1 \mid (\mathrm{C}_{m,i} \wedge ((a1 = \mathtt{a2}) \vee (a1 = \mathtt{a3}) \vee (a1 = \mathtt{a4})) \wedge (\mathrm{ord(a1\_1)} = (\mathrm{ord(a1)} - 1)))$

---

cnstr_29$_{m,i,i1}$

$\mathrm{T\_Q}_{m,i1} \geq \mathrm{T\_Q}_{m,i} + \mathrm{G\_Q}_{m,i} + \mathrm{S\_Q}$ $\forall m, i, i1 \mid (\mathrm{C}_{m,i} \wedge (\mathrm{ord(i1)} = (\mathrm{ord(i)} + 1)) \wedge \mathrm{C}_{m,i1})$

---

cnstr_30$_{m,i,n,j}$

$\mathrm{T\_Q}_{n,j} \geq \mathrm{T\_Q}_{m,i} + \mathrm{G\_Q}_{m,i}$ $\forall m, i, n, j \mid \mathrm{psi\_1}_{m,i,n,j}$

---

cnstr_31$_{m,i,n,j}$

$\mathrm{T\_Y}_{n,j} \geq \mathrm{T\_Y}_{m,i} + \mathrm{G\_Y}_{m,i}$ $\forall m, i, n, j \mid \mathrm{psi\_2}_{m,i,n,j}$

---

cnstr_32$_{m,i}$

$$\mathrm{T\_Y}_{m,i} \geq \mathrm{T\_start}_{m,i,\mathtt{a3}} + \mathrm{t\_AGV}_{m,i,\mathtt{a2},m,i,\mathtt{a3}} \qquad \forall m,i \mid \mathrm{D}_{m,i}$$

---

cnstr_33$_{m,i}$

$$\mathrm{T\_Q}_{m,i} \geq \mathrm{T\_start}_{m,i,\mathtt{a3}} + \mathrm{t\_AGV}_{m,i,\mathtt{a2},m,i,\mathtt{a3}} \qquad \forall m,i \mid \mathrm{L}_{m,i}$$

---

cnstr_34$_{m,i,n,j}$

$$\mathrm{T\_Y}_{n,j} + \mathrm{Mnum} \cdot (1 - \sum_{li} \mathrm{z}_{m,i,n,j,li}) \geq \mathrm{T\_start}_{m,i,\mathtt{a4}} + \mathrm{t\_AGV}_{m,i,\mathtt{a3},m,i,\mathtt{a4}} \; \forall m,i,n,j \mid (\mathrm{D}_{m,i} \wedge \mathrm{L}_{n,j})$$

---

cnstr_35$_{m,i,n,j}$

$$\mathrm{T\_Q}_{n,j} + \mathrm{Mnum} \cdot (1 - \sum_{li} \mathrm{z}_{m,i,n,j,li}) \geq \mathrm{T\_start}_{m,i,\mathtt{a4}} + \mathrm{t\_AGV}_{m,i,\mathtt{a3},m,i,\mathtt{a4}} \; \forall m,i,n,j \mid (\mathrm{L}_{m,i} \wedge \mathrm{D}_{n,j})$$

---

cnstr_36$_{m,i,a}$

$$\mathrm{T\_start}_{m,i,a} \geq \mathrm{T\_Y}_{m,i} + \mathrm{G\_Y}_{m,i} \qquad \forall m,i,a \mid (\mathrm{D}_{m,i} \wedge (a = \mathtt{a4}) \vee \mathrm{L}_{m,i} \wedge (a = \mathtt{a1}))$$

---

cnstr_37$_{m,i,a}$

$$\mathrm{T\_start}_{m,i,a} \geq \mathrm{T\_Q}_{m,i} + \mathrm{G\_Q}_{m,i} \qquad \forall m,i,a \mid (\mathrm{D}_{m,i} \wedge (a = \mathtt{a1}) \vee \mathrm{L}_{m,i} \wedge (a = \mathtt{a4}))$$

---

cnstr_38$_{m,i,a1,a1\_1,n,j,a2}$

$$\mathrm{T\_start}_{n,j,a2} + \mathrm{Mnum} \cdot (1 - \mathrm{U\_AGV}_{m,i,a1,n,j,a2}) \geq \mathrm{T\_start}_{m,i,a1} + \mathrm{t\_AGV}_{m,i,a1\_1,m,i,a1} \; \forall m,i,a1,a1\_1,n,j,a2 \mid (\mathrm{WT}_{m,i,}$$
$$\mathrm{WT}_{n,j,a2} \wedge (\mathrm{ord}(\mathrm{a1\_1}) = (\mathrm{ord}(\mathrm{a1}) - 1)))$$

---

cnstr_39$_{m,i,a,XR}$

$$\mathrm{X\_position}_{m,i,a} = \mathrm{XR.val}[(\mathrm{P\_X.L}_{m,i,a,XR} = 1)] \qquad \forall m,i,a,XR \mid \mathrm{C}_{m,i}$$

---

cnstr_40$_{m,i,a,YR}$

$$\mathrm{Y\_position}_{m,i,a} = \mathrm{YR.val}[(\mathrm{P\_Y.L}_{m,i,a,YR} = 1)] \qquad \forall m,i,a,YR \mid \mathrm{C}_{m,i}$$

---

cnstr_41_1$_{m,i,a1,n,j,a2}$

$$\mathrm{t\_AGV}_{m,i,a1,n,j,a2} = \frac{\mathrm{X\_position}_{m,i,a1} - \mathrm{X\_position}_{n,j,a2} + \mathrm{Y\_position}_{m,i,a1} - \mathrm{Y\_position}_{n,j,a2}}{\mathrm{v}} \; \forall m,i,a1,n,j,a2 \mid (\mathrm{WT}_{m,i,a1} \wedge$$
$$\mathrm{WT}_{n,j,a2} \wedge ((\mathrm{X\_position.L}_{m,i,a1} \geq \mathrm{X\_position.L}_{n,j,a2}) \wedge (\mathrm{Y\_position.L}_{m,i,a1} \geq \mathrm{Y\_position.L}_{n,j,a2})))$$

---

cnstr_41_2$_{m,i,a1,n,j,a2}$

$\text{t\_AGV}_{m,i,a1,n,j,a2} = \frac{-\text{X\_position}_{m,i,a1}+\text{X\_position}_{n,j,a2}-\text{Y\_position}_{m,i,a1}+\text{Y\_position}_{n,j,a2}}{\text{v}} \; \forall m,i,a1,n,j,a2 \mid (\text{WT}_{m,i,a1} \wedge \text{WT}_{n,j,a2} \wedge ((\text{X\_position.L}_{m,i,a1} \leq \text{X\_position.L}_{n,j,a2}) \wedge (\text{Y\_position.L}_{m,i,a1} \leq \text{Y\_position.L}_{n,j,a2})))$

---

cnstr_41_3$_{m,i,a1,n,j,a2}$

$\text{t\_AGV}_{m,i,a1,n,j,a2} = \frac{\text{X\_position}_{m,i,a1}-\text{X\_position}_{n,j,a2}-\text{Y\_position}_{m,i,a1}+\text{Y\_position}_{n,j,a2}}{\text{v}} \; \forall m,i,a1,n,j,a2 \mid (\text{WT}_{m,i,a1} \wedge \text{WT}_{n,j,a2} \wedge ((\text{X\_position.L}_{m,i,a1} \geq \text{X\_position.L}_{n,j,a2}) \wedge (\text{Y\_position.L}_{m,i,a1} \leq \text{Y\_position.L}_{n,j,a2})))$

---

cnstr_41_4$_{m,i,a1,n,j,a2}$

$\text{t\_AGV}_{m,i,a1,n,j,a2} = \frac{-\text{X\_position}_{m,i,a1}+\text{X\_position}_{n,j,a2}+\text{Y\_position}_{m,i,a1}-\text{Y\_position}_{n,j,a2}}{\text{v}} \; \forall m,i,a1,n,j,a2 \mid (\text{WT}_{m,i,a1} \wedge \text{WT}_{n,j,a2} \wedge ((\text{X\_position.L}_{m,i,a1} \leq \text{X\_position.L}_{n,j,a2}) \wedge (\text{Y\_position.L}_{m,i,a1} \geq \text{Y\_position.L}_{n,j,a2})))$

$\text{T\_Q}_{m,i} \geq 0 \; \forall m,i$
$\text{T\_Y}_{m,i} \geq 0 \; \forall m,i$
$\text{z}_{m,i,m,i,li} \in \{0,1\} \; \forall m,i,m,i,li$
$\text{P\_X}_{m,i,a,XR} \in \{0,1\} \; \forall m,i,a,XR$
$\text{P\_Y}_{m,i,a,YR} \in \{0,1\} \; \forall m,i,a,YR$
$\text{U\_AGV}_{m,i,a,m,i,a} \in \{0,1\} \; \forall m,i,a,m,i,a$
$\text{U\_QC}_{m,i,m,i,a} \in \{0,1\} \; \forall m,i,m,i,a$
$\text{T\_start}_{m,i,a} \geq 0 \; \forall m,i,a$
$\text{t\_AGV}_{m,i,a,m,i,a} \geq 0 \; \forall m,i,a,m,i,a$
$\text{X\_position}_{m,i,a} \geq 0 \; \forall m,i,a$
$\text{Y\_position}_{m,i,a} \geq 0 \; \forall m,i,a$