Efficient Freight Movement &Transportation Modeling

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creative | BOLD | determined

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Research Needs

Meeting ever increasing customer expectations
Efficient uses of transportation networks
Leaner and greener operations
Stay competitive

Logistics Modeling in Large Scale Disaster Relief

Minimize *Total Unsatisfied Weighted Demand*

Subject to:

- *Commodity Flow Constraints*
- *Vehicular Flow Constraints*
- *Constraints that Link Commodities and Vehicles*
- *Facilities Location Constraints*
- *Facility Capacities Constraints*
- *Equity (recipients/commodities) Constraints*

Minimize $$\sum_{i \in V} \sum_{t} \sum_{c} RU_{it}^{c} \cdot UD_{it}^{c}$$

Equity Constraint:

$$\frac{\sum_{t'} \sum_{m} \sum_{j} X_{ji(t'-t_{jim})}^{cm}}{\sum_{t'} Dem_{it'}^{c}} \geq \alpha_{\min} \qquad \forall i \in POD, c, t$$

$$\frac{\sum_{t'} \sum_{m} \sum_{j} X_{ji(t'-t_{jim})}^{cm}}{\sum_{c} \sum_{t'} \sum_{m} \sum_{j} X_{ji(t'-t_{jim})}^{cm}} \geq \beta_{\min} \qquad \forall i \in POD, c, t$$

$$\frac{\sum_{c} \sum_{t'} \sum_{m} \sum_{j} X_{ji(t'-t_{jim})}^{cm}}{\sum_{i} \sum_{c} \sum_{t'} \sum_{m} \sum_{j} X_{ji(t'-t_{jim})}^{cm}} \geq \gamma_{\min} \qquad \forall i \in POD, t$$

Facility Location and Capacities for Temporary Facilities

$$\sum_{c} \sum_{j} X_{ijt}^{cm} \leq Lcap_{it}^{m} \times Loc_{i}^{t} \qquad \forall i \in W, m, t$$

$$\sum_{c} \sum_{j} X_{ji(t-t_{jim})}^{cm} \leq Ucap_{it}^{m} \times Loc_{i}^{t} \qquad \forall i \in W, m, t$$

Logistics Modeling in Large Scale Disaster Relief

Supply nodes and Transfer nodes:

$$\sum_j X^{cm}_{ji(t-t_{jim})} + \sum_{m'} XT^{cm'm}_{i(t-k_{m'm})} + CX^{c}_{i(t-1)} + Sup^{c}_{it}$$

$$= \sum_j X^{cm}_{ijt} + \sum_{m'} XT^{mm'}_{it} + CX^{c}_{it} \qquad \forall i \in U, c, m, t$$

Facility Capacities for Permanent Facilities

$$\sum_c \sum_j X^{cm}_{ijt} \le Lcap^{m}_{it} \qquad \forall i \in V, m, t$$

$$\sum_c \sum_j X^{cm}_{ji(t-t_{jim})} \le Ucap^{m}_{it} \qquad \forall i \in LC, m, t$$

Demand nodes:

$$\sum_m \sum_j X^{cm}_{ji(t-t_{jim})} + UD^{c}_{it} = Dem^{c}_{it} + UD^{c}_{i(t-1)} \qquad \forall i \in POD, c, t$$

Vehicular Flow Constraints

$$\sum_j Y^{m}_{ji(t-t_{jim})} + CY^{m}_{i(t-1)} + AV^{m}_{it} = \sum_j Y^{m}_{ijt} + CY^{m}_{it} \qquad \forall i \in N, m, t$$

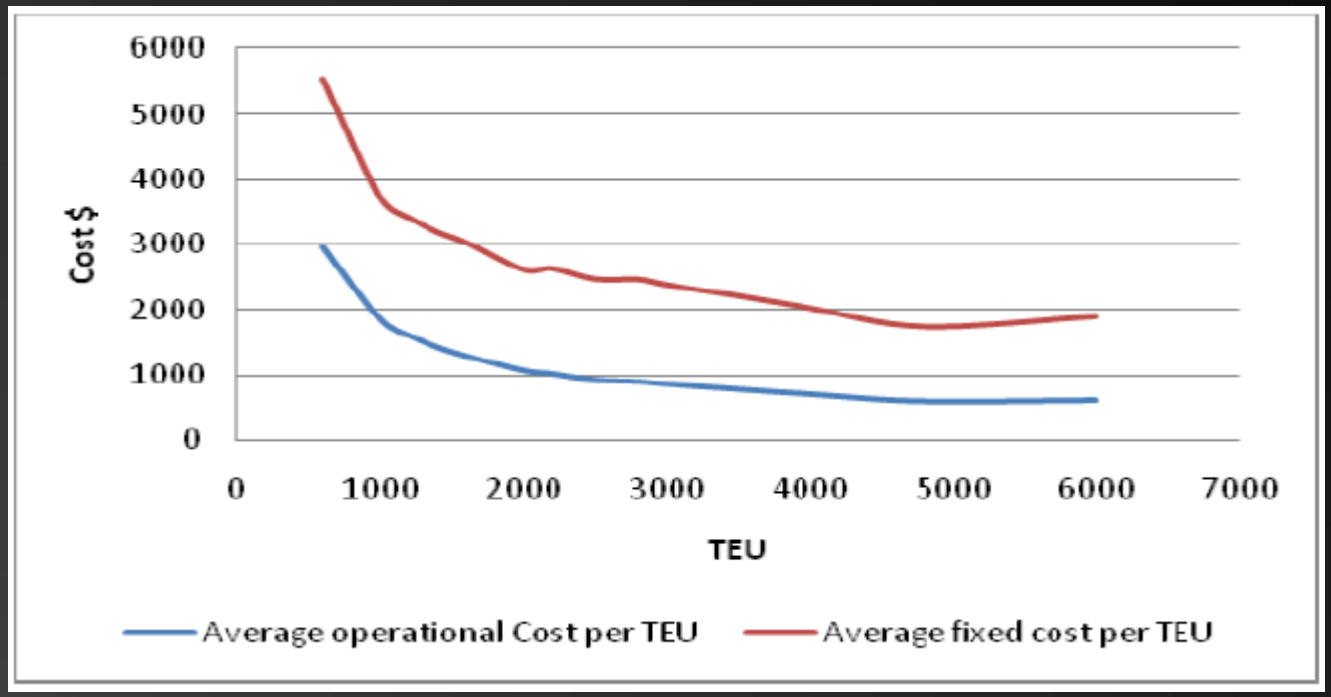
Linkage between Commodities and Vehicles

$$Cap_m \times Y^{m}_{ijt} \ge \sum_c w_c X^{cm}_{ijt} \qquad \forall i \in N, m, t$$

Capacities for PODs:

$$\sum_c \sum_j X^{cm}_{ji(t-t_{jim})} \le Ucap^{m}_{it} \qquad \forall i \in POD, m, t$$

Cost Reduction Strategies for Maritime Shipping Industry



Cost Reduction Strategies for Maritime Shipping Industry

$$C = P \times \sum_{i,j,k} \left\{ \left[MF_k \times \left(\frac{S_{1k}}{S_{0k}} \right)^3 + AF_k \right] \times \frac{d_{ij}}{24 \times S_{1k}} \right\}$$

$$AI_i = \frac{PA_i^2 / P_i / S_i}{\sum_j PA_j^2 / P_j / S_j} \quad \ldots\ldots$$

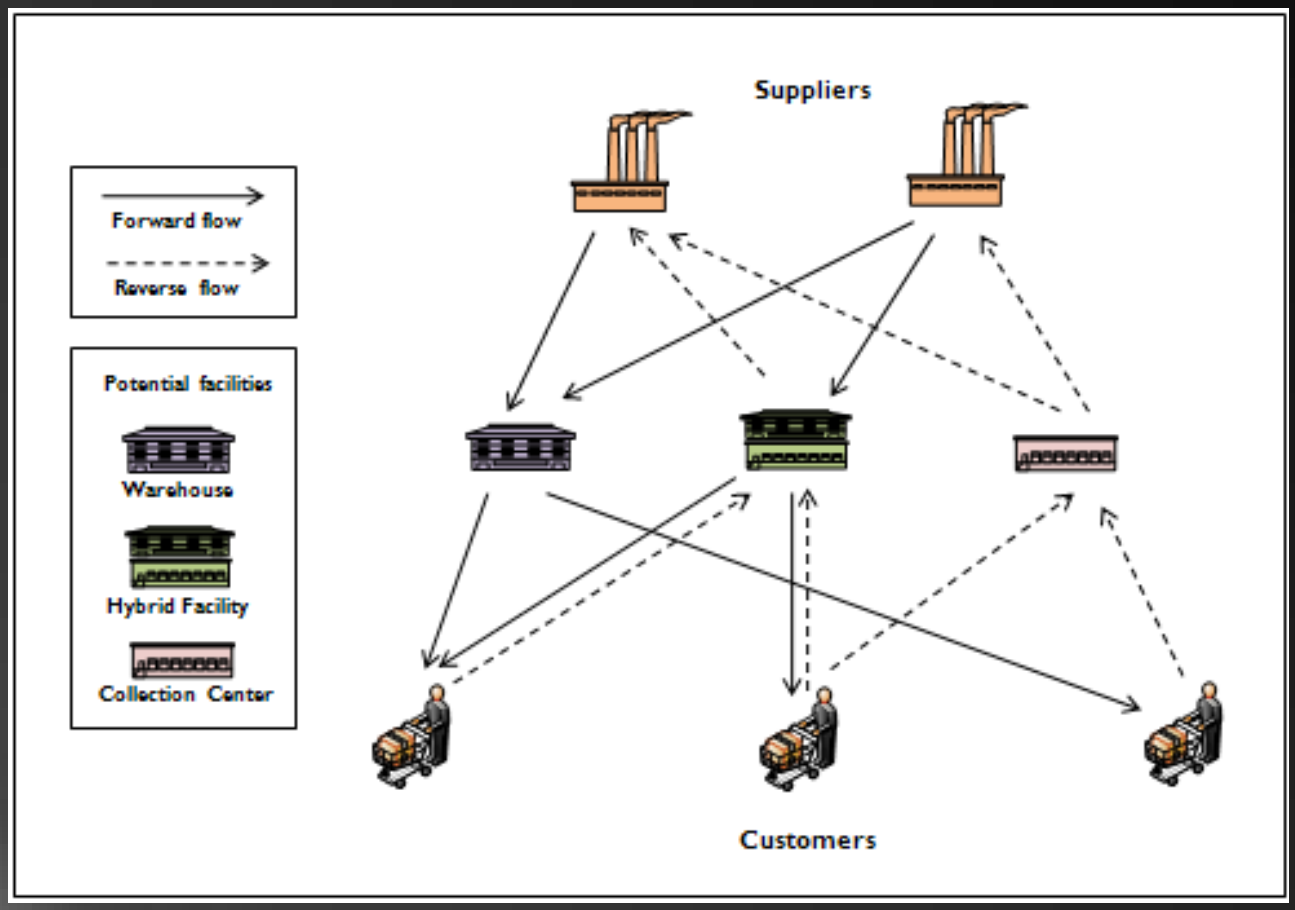
$$TI_i = avg\left(\frac{TA_i}{\sum_j TA_j}, \frac{LA_i}{\sum_j LA_j}\right) \quad \ldots\ldots$$

$$RRI_i = avg\left(\frac{PR_i^2 / P_i / S_i}{\sum_j PR_j^2 / P_j / S_j}, \frac{RR_i^2 / P_i / S_i}{\sum_j RR_j^2 / P_j / S_j}\right) \quad \ldots\ldots$$

$$EI_i = \frac{EP_i^2 / P_i / S_i}{\sum_j EP_i^2 / P_j / S_j} \quad \ldots\ldots$$

Speed Reduction Rate	Scenario 1 (million tons)	Average Fuel Savings per voyage (tons)	Scenario 2 (million tons)	Average Fuel Savings per Voyage (tons)
10%	7.3	120	4.0	60
20%	13.8	220	8.4	135
30%	19.4	310	13.0	200
40%	24.2	390	17.5	280
50%	28.0	450	21.6	350

Modeling Forward and Reverse Logistics Operations for 3PL



Modeling Forward and Reverse Logistics Operations for 3PL

$$TC = \sum_{t \in T, t \geq 1} \{SC(j,t) + FOC(j,t) + VC(p,i,j,k,t)\}$$

$$SC(j,t) = \sum_{j \in J} sw_{jt} A_{jt} (1 - A_{jt-1}) + \sum_{j \in J} sh_{jt} C_{jt} (1 - C_{jt-1}) + \sum_{j \in J} sc_{jt} E_{jt} (1 - E_{jt-1})$$

$$FOC(j,t) = \sum_{j \in J} ow_{jt} A_{jt} + \sum_{j \in J} oh_{jt} C_{jt} + \sum_{j \in J} oc_{jt} E_{jt}$$

$$VC(p,i,j,k,t,s) = \sum_{p \in P} \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} X_{pijkt} cf_{pijkt} + \sum_{p \in P} \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} Y_{pkjit} cr_{pkjit}$$

$$TT = \sum_{t \in T, t \geq 1} vot \times \{ \sum_{p \in P} \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} tf_{pijkt} X_{pijkt}$$

$$+ \sum_{p \in P} \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \sum_{s \in S} tr_{pkjit} Fr_{pkt} Y_{pkjits}$$

$$+ \sum_{p \in P} \sum_{i \in I} \sum_{j \in J} \sum_{k \in K} \sum_{s \in S} (tf_{pijkt} + tr_{pkjit} + rt_{pit}) Fp_{pkt} Y_{pkjits} \}$$

Modeling Forward and Reverse Logistics Operations for 3PL

$$(1)\quad \sum_{p\in P}\sum_{i\in I}\sum_{k\in K}\gamma_p X_{pijkt} \le Q_{jt}A_{jt} + R_{jt}C_{jt}, \forall j \in J, t \in T$$

$$(2)\quad \sum_{p\in P}\sum_{i\in I}\sum_{k\in K}\gamma_p Y_{pkjit} \le L_{jt}E_{jt} + U_{jt}C_{jt}, \forall j \in J, t \in T$$

$$(3)\quad \sum_{p\in P}\sum_{j\in J}\sum_{k\in K} X_{pijkt} \le M_{it}, \forall i \in I, t \in T$$

$$(4)\quad \sum_{i\in I}\sum_{j\in J} X_{pijkt} \ge d_{pkt}, \forall p \in P, k \in K, t \in T$$

$$(5)\quad \sum_{i\in I}\sum_{j\in J} Y_{pkjit} \ge r_{pkt}, \forall p \in P, k \in K, t \in T$$

$$(6)\quad A_{jt} + C_{jt} + E_{jt} \le 1, \forall j \in J, t \in T$$

$$(7)\quad Fr_{pkt} + Fp_{pkt} = 1, \forall p \in P, k \in K, t \in T$$

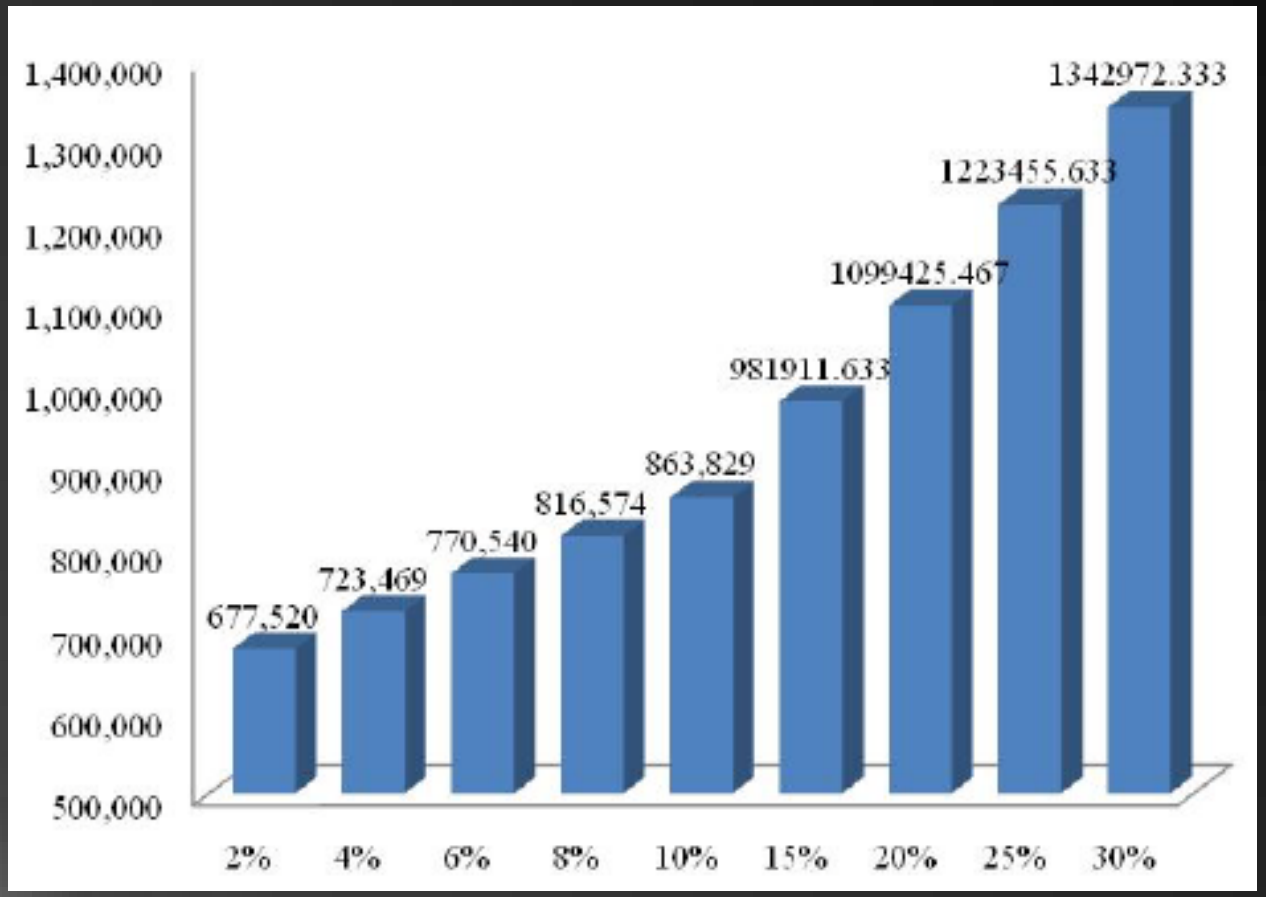
$$(8)\quad Fp_{pkt}, Fr_{pkt}, X_{pijkt}, Y_{pkjit} \ge 0, \forall p \in P, i \in I, \forall j \in J, k \in K, t \in T$$

$$(9)\quad A_{jt}, C_{jt}, E_{jt} \in \{0,1\}, \forall j \in J, t \in T$$

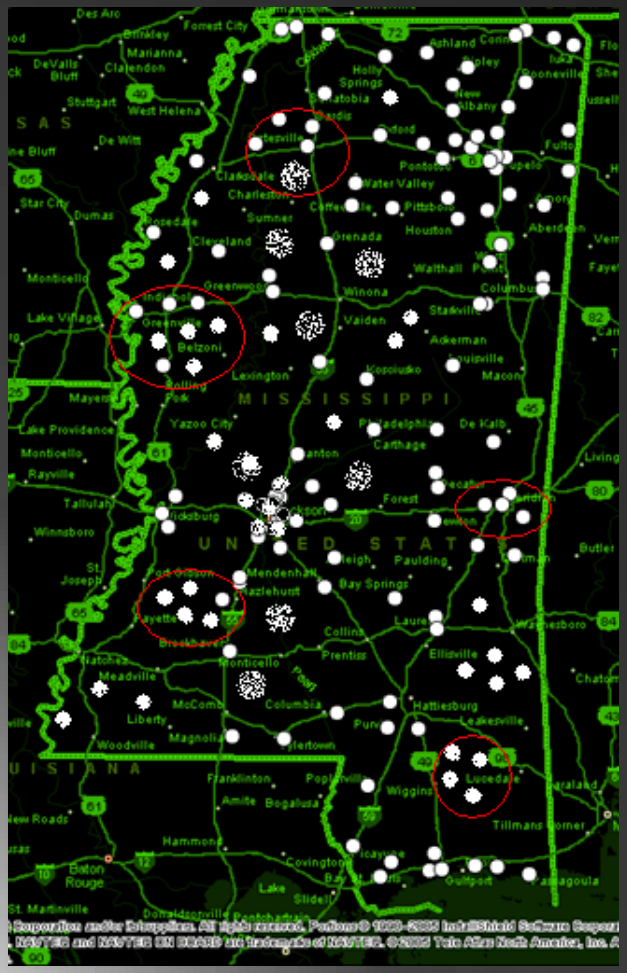
Modeling Forward and Reverse Logistics Operations for 3PL

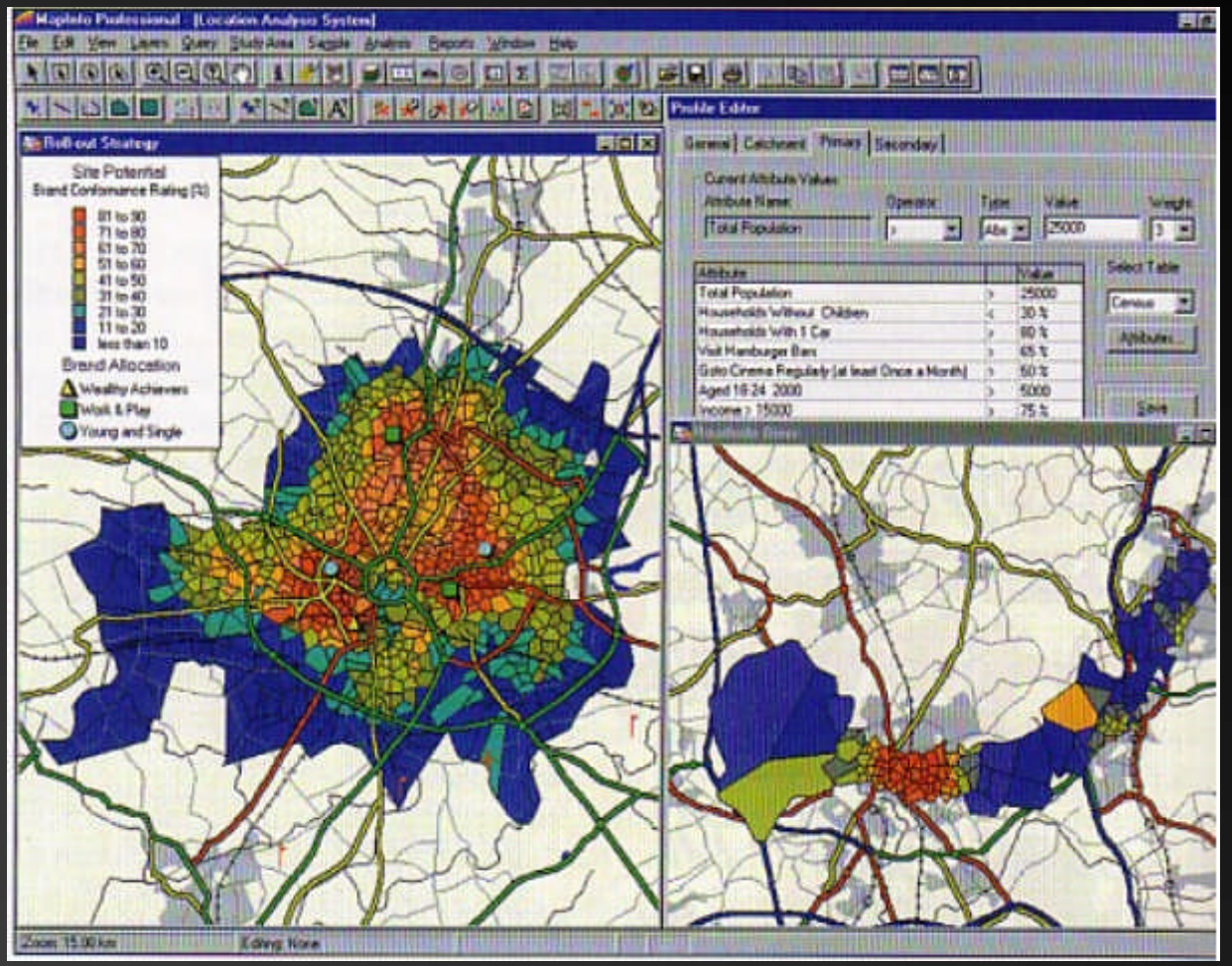
Return rate (%)	Total cost with hybrid facility ($)	Total cost without hybrid facility ($)	Cost savings ($)
2.0	677,520	683,623	6,103
4.0	723,470	731,216	7,747
6.0	770,540	778,867	8,327
8.0	816,574	826,460	9,885
10.0	863,829	874,469	10,640
15.0	981,912	994,036	12,125
20.0	1,099,425	1,113,325	13,899
25.0	1,223,456	1,232,954	9,499
30.0	1,342,972	1,352,181	9,208

Modeling Forward and Reverse Logistics Operations for 3PL

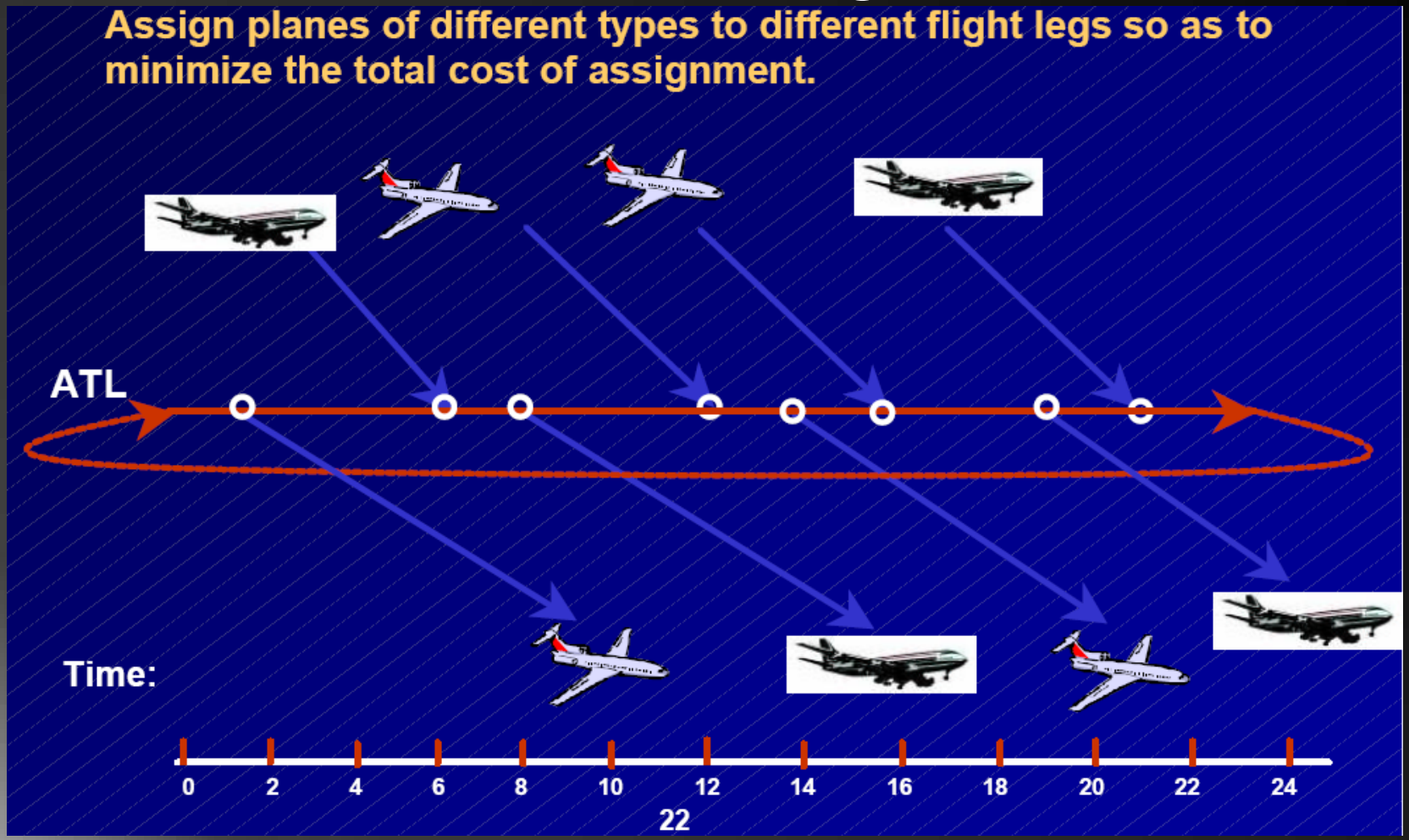


Locating Clusters/Hubs/Intermodal Facilities





Network Optimization in Transportation Scheduling



Network Optimization in Transportation Scheduling

Inbound Flights at Atlanta:

		City	Flight #:	Stops	Plane typ
6:00 AM	8:05 AM	Boston	709	0	???
6:30 AM	8:39 AM	JFK	538	0	???
12:25 PM	4:27 PM	DC	746	0	???
2:25 PM	6:13 PM	Philly	646	0	???

Outbound Flights at Atlanta:

6:00 AM	8:05 AM	Houston	657	0	???
6:30 AM	8:39 AM	Austin	987	0	???
12:25 PM	4:27 PM	Dallas	564	0	???
2:25 PM	6:13 PM	Phoenix	367	0	???

Network Optimization in Transportation Scheduling

Inbound Flights at Atlanta:

		City	Flight #:	Stops	Plane type
6:00 AM	8:05 AM	Boston	709	0	M80
6:30 AM	8:39 AM	JFK	538	0	757
12:25 PM	4:27 PM	DC	746	0	M80
2:25 PM	6:13 PM	Philly	646	0	757

Outbound Flights at Atlanta:

9:30 AM	11:45 AM	Houston	657	0	757
9:05 AM	11:00 AM	Austin	987	0	M80
7:00 PM	9:30 PM	Dallas	564	0	757
5:30 PM	7:45 PM	Phoenix	367	0	M80

Network Optimization in Transportation Scheduling

6:00 AM	11:00 AM	Boston	Austin	709/987	1	M80
6:30 AM	11:45 AM	JFK	Houston	538/657	1	757
12:25 PM	7:45 PM	DC	Phoenix	746/367	1	M80
2:25 PM	9:30 PM	Philly	Dallas	646/564	1	757

Thanks