USER'S MANUAL

for the

FREIGHT ANALYSIS PC SOURCING SYSTEM

SYSTEM OVERVIEW

The function of this system is to find a least cost solution for supplying vehicles to sales districts from assembly plants.

The costs involved vary from plant to plant and between plants and districts, making this a complex task, unsuitable for manual calculation. The system employs Linear Programming (LP) techniques to find the least cost solution.

The following costs are taken into account when finding the least cost solution.

- Inbound Freight Costs
- Premium Inbound Freight Costs
- Manufacturing Straight Time Costs
- Manufacturing Weekday Overtime Costs
- Manufacturing Saturday Overtime Costs
- Downtime Costs
- Outbound Freight Cost
- Transit Costs
- Ramp Costs

The following constraints are also taken into account when finding the least cost solution.

- Normal Plant Capacities
- Weekday Overtime Capacities
- Saturday Overtime Capacities

- Sales District Forecasts

The problem size limitations of the system are as follows:

- Maximum of 5 plants per carline.

- Maximum of 29 U.S. sales districts.

- Maximum of 7 Canadian sales districts.

FREIGHT ANALYSIS
LINEAR PROGRAM FORMULATION

The following standard LP formulation is used to solve the Freight Analysis Sourcing System problem. This LP finds the least cost solution of sourcing vehicles to assembly plants in order to meet vehicle sales forecast for sales districts.

The Objective Function minimizes manufacturing and freight costs. These costs include inbound freight and premium inbound freight; manufacturing straight time, overtime, and downtime; and outbound freight costs.

The LP is constrained by the following constraints:

1. The number of vehicles shipped to each sales district must equal the sales district forecast.

2. The number of vehicles sourced to each plant must not exceed that plants normal and overtime capacities. Also, if the number of vehicles sourced to a plant is less than the plant's normal capacities, downtime units (units representing unused capcity) must makeup the difference.

3. The number of weekday overtime units sourced to each plant must be less than or equal to the plants weekday overtime capacity.

4. The number of Saturday overtime units sourced to each plant must be less than or equal to the plants Saturday overtime capacity.

FREIGHT ANALYSIS
LINEAR PROGRAM FORMULATION

Variable Definition:

i = plant
j = sales district

OB_{ij} = outbound shipping cost from plant i to district j
IB_i = inbound freight cost to plant i
MSC_i = manufacturing straght time cost at plant i

x_{ij} = quantity shipped from plant i to sales district j

WOT_i = weekday overtime cost at plant i
z_i = quantity of weekday overtime at plant i

SOT_i = Saturday overtime cost at plant i
q_i = quantity of Saturday overtime at plant i

DT_i = downtime cost at plant i
w_i = quantity of downtime at plant i

DR_j = district requirements for region j

PC_i = straight time capacity at plant i
WOC_i = weekday overtime capacity at plant i
SOC_i = Saturday overtime capacity at plant i

Objective Function:

$$\text{Min} \sum_i \sum_j (OB_{ij} + IB_i + MSC_i)\, x_{ij} + (WOT_i)\, z_i + (SOT_i)\, q_i + (DT_i)\, w_i$$

Subject To:

$$\sum_i x_{ij} = DR_j \qquad \text{for } j = 1,2,\ldots.36$$

$$\sum_j x_{ij} + w_i - z_i - q_i = PC_i \qquad \text{for } i = 1,2,..5$$

$$z_i \leq WOC_i \qquad \text{for } i = 1,2$$

$$q_i \leq SOC_i \qquad \text{for } j = 1,2$$

INPUT COSTS AND CONSTRAINTS REPORT

This report provides all the costs and constraints input by the user to find the least cost sourcing solution for a given carline.

The following Input Costs Report example has highlighted those cells which can be edited. Do not edit any cells which are not highlighted.

The first page begins with a TITLE of the carline being analyzed. Only this occurrence of the Title should be edited, all other Titles will reflect a change to this title.

Following the Title are all the cost parameters for each plant. The plant names are also specified. Only this occurrence of the plant names should be edited. All other occurrences of the plant names will reflect the changes to these plant names.

Next are the normal, weekday overtime, and Saturday overtime plant capacities, followed by the total U.S. and Canadian Sales forecasts. All plant capacities are then totaled, followed by the total US and Canada Sales forecast. The total sales forecast must be less than the total plant capacities or there will be no possible least cost sourcing solution.

The following three pages of the Input Report contain the outbound freight costs for each sales district and the percent sales forecast for each district. The percent sales forecast can be changed for any district, but the total percent must be 100% for both the U.S. and Canada. The total units forecast for each district is calculated from the percent district sales forecast and the total US or Canada forecast.

The outbound freight costs are divided into three costs for each plant and district. The first cost is the transportation cost. The second cost is the ramp cost. And, the third cost is the transit cost.

B&A Controllers Sourcing System

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FREIGHT ANALYSIS SOURCING SYSTEM

TITLE: 1988 LIGHT TRUCK

COST PARAMETERS

		NOR	OTP	MTP	TCT	KCT
Normal Inbound	($/unit)	202	114	80	174	210
Premium Inbound	($/unit)	11	12	8	15	14
Manufacturing Straight Time	($/unit)	227	212	274	260	237
Overtime Weekday	($/unit)	141	116	154	140	124
Overtime Saturday	($/unit)	171	131	202	181	144
Downtime Cost	($/unit)	173	39	210	205	197

OPERATING PARAMETERS

		NOR	OTP	MTP	TCT	KCT
Normal Capacity	(1000s unit	3224	3040	1480	1376	1240
Weekday Overtime	(1000s unit	806	608	370	344	310
Saturday Overtime	(1000s unit	645	0	296	277	248
Total Plant Capacities		4675	3648	2146	1997	1798

SALES FORECAST

Total Units US Forecast	8100.0
Total Units Can. Forecast	900.0

Grand Total Plant Capacities 14264

Total Sales Forecast (US and CAN) 9000

WARNING ***WARNING*** ***WARNING***
Grand Total Plant Capacities must be greater than Total Sales Capacities
or result will be NO SOLUTION

Shipping Costs, Percent Sales Forecast & Volume Sales Forecast by Sales Distr
1988 LIGHT TRUCK

Sales District	% Sales Forecast	Units Forecast	Outbound Shipping Cost MOR	OTP	MTP	TCT	KCT
U.S.							
Bost	5.5%	445.5	347	242	269	434	412
			9	19	8	7	10
			50	30	37	52	39
Buff	2.4%	194.4	310	162	254	403	401
			9	0	1	7	10
			31	16	11	38	32
Newy	3.4%	275.4	223	231	257	394	412
			9	9	8	7	10
			45	29	38	41	40
Pitt	2.1%	170.1	243	224	216	391	385
			0	0	0	7	17
			10	16	10	46	40
Phil	4.4%	356.4	223	221	229	384	405
			9	8	8	7	10
			47	27	28	32	35
Wash	6.0%	486.0	123	274	236	390	388
			0	10	9	8	11
			10	33	39	38	38
Atla	3.5%	283.5	202	326	244	317	255
			3	9	8	7	10
			16	38	37	38	37
Char	3.8%	307.8	146	345	249	346	328
			1	9	8	7	10
			14	33	45	42	40
Hemp	2.4%	194.4	281	300	233	292	208
			9	9	8	7	6
			33	39	36	38	24
Jack	4.8%	388.8	250	405	312	397	345
			9	9	8	7	10
			28	36	39	47	42
N.O.	2.7%	218.7	301	376	277	371	270
			8	9	8	7	10

PENALTY COST REPORT

The Penalty Cost Report is a myopic look at the least Total and Outbound penalty per plant/district.

The following computations are performed to produce this report.

1. Total Penalty (Total) per plant/district = penalty per plant - best penalty for that district. (penalty is: mfg. + ramp + transit + transportation + inbound + premium)

2. Outbound (O/B) per plant district = transportation - best transportation for that district.

3. Totals per region (also US and Canada totals)

   A. line 1. percent totals for Total and O/B: sum of percent of sales for least cost Total or O/B, 1 Total and Outbound for each district.

   B. line 2. outbound costs after selection of the best plants.

Each of the four worksheet structures will have a slightly different Penalty Cost report. The 5 plant model has been included in this report. The 4 plant model will not contain the last plant Total and O/B columns. Likewise, the 3 plant model will not contain the last 2 plants, and the 2 plant model will not contain the last 3 plants.

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SOURCING COSTS
1988 LIGHT TRUCK

	NOR		OTP		MTP		TCT		KCT		
	TOTAL	O/B	TOTAL	O/B	TOTAL	O/B	TOTAL	O/B	TOTAL	O/B	
Bost	217	105	0	0	67	47	313	192	293	170	5.5%
Buff	274	148	0	0	112	92	381	241	368	239	2.4%
Newy	110	0	0	8	58	34	284	171	316	189	3.4%
Pitt	115	27	0	8	10	0	315	175	325	169	2.1%
Phil	125	2	0	0	33	8	278	163	317	184	4.4%
Wash	0	0	82	151	73	113	312	267	325	265	6.0%
TOTAL NOEA REGION	6.0%	9.4% 159.2	17.8%	12.3% 218.9	0.0%	2.1% 216.0	0.0%	0.0% 0.0	0.0%	0.0% 0.0	23.8% 195.0
Atla	10	0	60	124	0	42	160	115	112	53	3.5%
Char	0	0	124	199	63	103	243	200	238	182	3.8%
Memp	124	73	47	92	0	25	147	84	60	0	2.4%
Jack	6	0	67	155	0	62	179	147	137	95	4.8%
N.O.	72	31	58	106	0	27	161	101	69	0	2.7%
Loui	127	48	76	80	0	0	184	78	135	21	2.3%
TOTAL SOEA REGION	3.8%	12.1% 203.5	0.0%	0.0% 0.0	15.7%	2.3% 193.0	0.0%	0.0% 0.0	0.0%	5.1% 240.8	19.5% 212.0
Chic	349	231	107	116	0	0	144	43	189	74	2.8%
Clev	241	131	54	72	0	0	281	155	291	149	2.5%
Milw	295	240	91	170	3	73	0	0	144	94	2.3%
Indi	231	128	96	114	0	0	219	100	248	139	1.9%
Cinn	60	0	82	111	0	9	224	126	179	76	2.5%
Detr	360	251	94	112	0	0	248	126	293	163	4.0%
TOTAL GRLK REGION	0.0%	2.5% 196.0	0.0%	0.0% 0.0	13.7%	11.2% 125.5	2.3%	2.3% 154.0	0.0%	0.0% 0.0	16.0% 140.6
Dall	196	204	148	248	92	174	99	95	0	0	6.4%
K.C.	348	326	180	267	124	182	117	97	0	0	3.8%
Omah	102	0	0	0	24	0	111	0	123	0	0.0%
StLo	200	178	67	152	16	75	75	55	0	0	2.8%
Hous	154	157	147	243	103	175	116	114	0	0	5.2%
T.C.	447	416	190	253	122	167	0	0	161	115	5.0%
TOTAL CENT REGION	0.0%	0.0% 0.0	0.0%	0.0% 0.0	0.0%	0.0% 0.0	5.0%	5.0% 109.0	18.2%	18.2% 193.7	23.2% 175.5
LosA	270	287	103	215	100	191	52	63	0	0	5.9%
SanJ	273	261	238	346	103	194	38	47	0	0	4.7%
Seat	509	496	89	185	0	91	1	0	184	168	2.3%
Phix	102	0	0	0	24	0	111	0	125	0	0.0%
Denv	374	361	145	243	93	175	35	36	0	0	4.5%
TOTAL WEST REGION	0.0%	0.0% 0.0	0.0%	0.0% 0.0	2.3%	0.0% 0.0	0.0%	2.3% 433.0	15.2%	15.2% 463.0	17.5% 459.0

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TOTAL US -	9.8%	24.0% 185.3	17.8%	12.3% 218.9	31.7%	15.6% 147.6	7.5%	9.6% 197.4	33.4%	38.5% 306.3	100.0% 251.3
Canada											
Atlc	416	253	0	0	119	85	401	277	429	285	10.7%
East	365	233	0	0	152	116	422	282	426	268	11.7%
Cent	401	271	0	0	195	168	423	273	421	258	13.4%
Lake	387	257	0	0	147	123	424	273	413	252	16.8%
MidW	401	278	0	48	81	94	65	0	193	91	13.3%
West	376	253	0	31	69	63	82	0	242	126	20.6%
Pacf	512	387	0	0	67	44	118	13	288	133	11.5%
TOTAL CAHA REGION	0.0%	0.0% 0.0	100.0%	66.1% 227.8	0.0%	0.0% 0.0	0.0%	33.9% 383.7	0.0%	0.0% 0.0	100.0% 260.6

SOURCING SUMMARY REPORT

The Sourcing Summary Report shows the least cost sourcing pattern by plant and district. This should give the analyst a quick view of where vehicles are being sourced and which districts are split sourced. Total sourced plant volumes are also provided.

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SOURCING PLAN RESULTS
1988 LIGHT TRUCK

District	NOR	OTP	MTP	TCT	KCT	TOTAL
U.S.						
Bost	0.0	445.5	0.0	0.0	0.0	445.5
Buff	0.0	194.4	0.0	0.0	0.0	194.4
Newy	275.4	0.0	0.0	0.0	0.0	275.4
Pitt	170.1	0.0	0.0	0.0	0.0	170.1
Phil	216.3	140.1	0.0	0.0	0.0	356.4
Wash	486.0	0.0	0.0	0.0	0.0	486.0
Atla	283.5	0.0	0.0	0.0	0.0	283.5
Char	307.8	0.0	0.0	0.0	0.0	307.8
Memp	194.4	0.0	0.0	0.0	0.0	194.4
Jack	388.8	0.0	0.0	0.0	0.0	388.8
N.O.	218.7	0.0	0.0	0.0	0.0	218.7
Loui	59.3	0.0	127.0	0.0	0.0	186.3
Chic	0.0	0.0	226.8	0.0	0.0	226.8
Clev	0.0	0.0	202.5	0.0	0.0	202.5
Milw	0.0	0.0	32.7	153.6	0.0	186.3
Indi	0.0	0.0	153.9	0.0	0.0	153.9
Cinn	202.5	0.0	0.0	0.0	0.0	202.5
Detr	0.0	0.0	324.0	0.0	0.0	324.0
Dall	0.0	0.0	0.0	0.0	518.4	518.4
K.C.	0.0	0.0	0.0	0.0	307.8	307.8
Omah	0.0	0.0	0.0	0.0	0.0	0.0
StLo	0.0	0.0	226.8	0.0	0.0	226.8
Hous	421.2	0.0	0.0	0.0	0.0	421.2
T.C.	0.0	0.0	0.0	405.0	0.0	405.0
LosA	0.0	0.0	0.0	64.1	413.8	477.9
SanJ	0.0	0.0	0.0	380.7	0.0	380.7
Seat	0.0	0.0	186.3	0.0	0.0	186.3
Phix	0.0	0.0	0.0	0.0	0.0	0.0
Denv	0.0	0.0	0.0	372.6	0.0	372.6
	3224.0	780.0	1480.0	1576.0	1240.0	8100.0
Canada						
Atlc	0.0	96.3	0.0	0.0	0.0	96.3
East	0.0	105.3	0.0	0.0	0.0	105.3
Cent	0.0	120.6	0.0	0.0	0.0	120.6
Lake	0.0	169.2	0.0	0.0	0.0	169.2
MidW	0.0	119.7	0.0	0.0	0.0	119.7
West	0.0	185.4	0.0	0.0	0.0	185.4
Pacf	0.0	103.5	0.0	0.0	0.0	103.5
	0.0	900.0	0.0	0.0	0.0	900.0
	3224.0	1680.0	1480.0	1576.0	1240.0	9000.0

RECAP SUMMARY BUILD AND COST REPORT

This report begins by showing the normal, weekday overtime, Saturday overtime and downtime units for each assembly plant, determined by the least cost solution.

The next section breaks down the costs of the least cost sourcing solution by plant. For each plant, a total cost is calculated, and a cost per unit is calculated. A total Outbound cost is supplied for each plant and is also presented as a separate US and Canadian Outbound cost.

The final column reports the total costs for the carline, including a total cost per unit.

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SUMMARY BUILD AND COSTS
1988 LIGHT TRUCK

Units Produced (1000s)	NOR	OTP	MTP	TCT	KCT	TOTAL
Straight Time	3224	1680	1460	1376	1240	9000
Weekday Overtime	0	0	0	0	0	0
Saturday Overtime	0	0	0	0	0	0
Downtime Units	0	1360	0	0	0	1360
Totals	3224	3040	1460	1376	1240	10360

Total Costs ($1000s)	NOR	$/car	OTP	$/car	MTP	$/car
Normal Inbound	651.2	202.0	191.5	114.0	118.4	80.0
Premium Inbound	35.5	11.0	20.2	12.0	11.8	8.0
Assembly (MFD)	731.8	227.0	356.2	212.0	405.5	274.0
Weekday Overtime	0.0	0.0	0.0	0.0	0.0	0.0
Saturday Overtime	0.0	0.0	0.0	0.0	0.0	0.0
Outbound	756.0	234.5	434.3	258.5	298.3	201.5
(U.S.)	(756.0)	(234.5)	(170.3)	(218.3)	(298.3)	(201.5)
(Can.)	0.0	0.0	(264.1)	(293.4)	0.0	0.0
Multi-Level	17.9	5.5	15.0	8.9	4.1	2.8
Transit	82.2	25.5	42.9	25.5	29.1	19.6
Downtime	0.0	0.0	53.0	31.6	0.0	0.0
Total	2,274.6	705.5	1,113.0	662.5	867.2	585.9

Total Costs ($1000s)	TCT	$/car	KCT	$/car	Tot. Cost	$/car
Normal Inbound	239.4	174.0	260.4	210.0	1,461.0	162.3
Premium Inbound	20.6	15.0	17.4	14.0	105.5	11.7
Assembly (MFD)	357.8	260.0	293.9	237.0	2,145.2	238.4
Weekday Overtime	0.0	0.0	0.0	0.0	0.0	0.0
Saturday Overtime	0.0	0.0	0.0	0.0	0.0	0.0
Outbound	457.6	332.5	358.0	288.7	2,304.2	256.0
(U.S.)	(457.6)	(332.5)	(358.0)	(288.7)	(2,040.1)	(251.9)
(Can.)	0.0	0.0	0.0	0.0	(264.1)	(293.4)
Multi-Level	5.7	4.2	6.7	5.4	49.4	5.5
Transit	35.6	25.9	28.4	22.9	218.1	24.2
Downtime	0.0	0.0	0.0	0.0	53.0	5.9
Total	1,116.7	811.6	964.8	778.1	6,336.3	704.0