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JUNK CAR PROBLEM

Richard E. BECKWITH[a)], Josef VOLEK[b)]

[a)]Professor of Operations Research and Statistics, School of Business Administration, California State University, Sacramento, [b)]Senior Lecturer, Department of Transport Techniques and Control, The Jan Perner Faculty of Transport, University Pardubice

1. Background

Worn-out and unusable trash automobiles, trucks, and miscellaneous other powered vehicles, henceforth called „Junk Cars", have been collecting throughout the Czech Republic for some years, becoming both a public nuisance and an eyesore. It is a appropriate to consider organized methods to control, if not outright eliminate, this situation.

2. Solution

An appealing possibility is the establishment, at suitable locations, of facilities devoted to the dismantling of Junk Cars and preparation of their salvageable components and materials for recycling; this could include salable used parts as well as raw materials such as steel, copper, glass, and rubber. It might be expected that in due course of time a profit/centered industry would develop independently to address these ends. Even so, a case can be advanced for the formal study of this problem, with the objective of outlining a system with less overall grief and total expense ... than might be expected if the job is left to market forces alone.

3. Elements

The overall Junk Car problem is perceived to consist of the following elements.

a) Identify the location for potential recycling facilities, henceforth called Recycling Centers. This will involve economic, engineering, and environmental impact studies of the possible locations, as well as the differing setup costs which may be expected to be involved.

b) Asses the quantity of Junk Cars in inventory at all Junk Car accumulation sites ... both large and small ... throughout the country, as well as econometric assessment of the accumulation-rate of Junk Cars into the future. In addition, a determination should be made of the unit cost of transporting Junk Cars from the various sites to each of the proposed recycling centres. This determination (in naive form) could involve no more than a table of the distances involved; compounding such a table could range from a practical "common sense" approach to the solution of a formal mathematical problem.

c) Determination of the "production horizon " for the recycling centres. This will necessitate the specification of a target date when the recycling process should reach statistical equilibrium, and will (of necessity) include a schedule for the processing of Junk Cars accumulated to date. (Mathematical models developed for epidemiological purposes may be helpful to this latter and.)

d) Determine which of the potential sites for the construction of recycling centres should (in fact) be established, and develop a schedule for the construction sequence. The first problem is solvable via Mathematical Programming Techniques, while the second could involve similar methodology, together with addressing the financial and legalistic issues which attend all construction tasks.

4. A small problem of "Junk car" form

Let there be S=7 „source site" of junk cars and R = 3 potential locations for their dismantlement, which we term „processing centres". Table 1 lists these sites and the cost of transporting one car from each to the different processing centres, as well as the supply of junk cars at each source location.

Table 1

Source	Cost to site			Supply
	1	2	3	
1	1	2	3	10
2	2	2	6	15
3	4	2	5	12
4	5	1	2	22
5	6	3	2	29
6	6	4	1	18
7	2	4	3	16

Table 2 lists the 3 processing centres, together with their costs of set up (or establishment), and their processing capacities if established.

Table 2

Processing Centre	Setup Cost	Capacity
1	150	50
2	160	60
3	170	70

For i=1 to 7 and j=1 to 3 let x_{ij} denote the number of junk cars which are directed from Source Site i to Processing Centre j. For j=1 to 3 let y_j =1 indicates that Processing centre j is established and y_j =0 indicates that Centre j is not established. Then the algebraic form of the

problem of transporting the junk cars at the various sources to the processing centres at minimum total cost can be expressed as the following fixed/cost integer/programming problem.

Minimize:

$$150y_1+160y_2+170y_3+x_{11}+2x_{12}+3x_{13}+2x_{21}+2x_{22}+6x_{23}+4x_{31}+2x_{32}+5x_{33}+5x_{41}+x_{42}+2x_{43}+6x_{51}+3x_{52}+2x_{53}+6x_{61}+4x_{62}+x_{63}+2x_{71}+4x_{72}+3x_{73}$$

subject to the conditions that all of the junk cars are processed:

$$x_{11}+x_{12}+x_{13}=10 \qquad x_{21}+x_{22}+x_{23}=15$$
$$x_{31}+x_{32}+x_{33}=12 \qquad x_{41}+x_{42}+x_{43}=22$$
$$x_{51}+x_{52}+x_{53}=29 \qquad x_{61}+x_{62}+x_{63}=18$$
$$x_{71}+x_{72}+x_{73}=16$$

and no processing capacity is exceeded:

$$50y_1-x_{11}-x_{21}-x_{31}-x_{41}-x_{51}-x_{61}-x_{71}\geq 0$$
$$60y_2-x_{12}-x_{22}-x_{32}-x_{42}-x_{52}-x_{62}-x_{72}\geq 0$$
$$70y_3-x_{13}-x_{23}-x_{33}-x_{43}-x_{53}-x_{63}-x_{73}\geq 0$$

together with all $x_{ij}\geq 0$ and integer and all $y_j=0$ or 1.

5. Solution

The solution to this problem, expressed in terms of the nonzero variables (only), is:

$y_2=1,\ y_3=1$
$x_{12}=10, x_{22}=15, x_{32}=12, x_{42}=22, x_{53}=29, x_{63}=18,$
and $x_{73}=16.$

All other variables equal zero. This solution achieves minimum Cost, at the value 550.

To the solution of the problem was used Linear, Interactive and Discrete Optimizer - LINDO, which enables to solve linear, integer, and quadratic programming models. Given the explicit algebraic formulation of the problem the commands GIN 24 and INTEGER 3 (in this order) set the integer requirements. An automatic solution needs to transfer the algebraic statements into MPS Format. The above problem in MPS format is given on the next page, and is printed for brevity in double columns. Also, certain trailing zeros have been provided for cosmetic effect. Comparison of the MPS format with algebraic statement of the problem shows how a larger problem can be prepared by program and/or word processor for importation into LINDO and automatic solution.

Junk Car Problem solution by LINDO

```
NAME    LINDO GENERATED MPS FILE (MIN)
ROWS
N1
E2
E3
E4
E5
E6
E7
E8
G9
G10
G11
COLUMNS
INTEGER1 'MARKER'      'INTROG'
Y1                1          150.0
Y1                9           50.0
Y2                1          160.0
Y2               10           60.0
Y3                1          170.0
Y3               11           70.0
INTEGER2 'MARKER'      'INTROG'
X11               1            1.00
X11               2            1.00
X11               9           -1.00
X12               1            2.00
X12               2            1.00
X12              10           -1.00
X13               1            3.00
X13               2            1.00
X13              11           -1.00
X21               1            2.00
X21               3            1.00
X21               9           -1.00
X22               1            2.00
X22               3            1.00
X22              10           -1.00
X23               1            6.00
X23               3            1.00
X23              11           -1.00
X31               1            4.00
X31               4            1.00
X31               9           -1.00
X32               1            2.00
X32               4            1.00
X32              10           -1.00
X33               1            5.00
X33               4            1.00
X33              11           -1.00
X41               1            5.00
X41               1            5.00
X42               1            1.00
X42               5            1.00
X42              10           -1.00
X43               1            2.00
X43               5            1.00
X43              11            2.00
X51               1            6.00
X51               6            1.00
X51               9           -1.00
X52               1            3.00
X52               6            1.00
X52              10           -1.00
X53               1            2.00
X53               6            1.00
X53              11           -1.00
X61               1            6.00
X61               7            1.00
X61               0           -1.00
X62               1            4.00
X62               7            1.00
X62              10           -1.00
X63               1            1.00
X63               7            1.00
X63              11           -1.00
X71               1            2.00
X71               8            1.00
X71               9           -1.00
X72               1            4.00
X72               8            1.00
X72              10           -1.00
X73               1            3.00
X73               8            1.00
X73              11           -1.00
RHS
RHS               2           10.00
                  3           15.00
                  4           12.00
                  5           22.00
                  6           29.00
                  7           18.00
                  8           16.00
BOUNDS
UP LINBOBD        Y1           1.00
                  Y2           1.00
                  Y3           1.00
```

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References

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Resumé

PROBLÉM OJETÝCH VOZŮ

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Přístupy k řešení problému alokace a lokace recyklačních center pro „ojetá" vozidla v prostoru České republiky vycházejí z aktuálního stavu, předpokládaného vývoje a zamýšleného cílového stavu. Současný stav likvidace opotřebených vozidel v ČR není příliš povzbuzující. Článek je příspěvkem k diskusi o možnostech analytického řešení lokalizace recyklačních středisek a modelování systému likvidace ojetých osobních i nákladních automobilů.

Summary

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The approach to the allocation/location problem solution of the recycling centres of used cars in the Czech Republic issues from the actual state, presumed development and designed target state. The actual state of used cars treatment in the CR is not very encouraging. The article presents the contribution to the discussion of analytical possibilities of recycling centres location and used personal cars and lorries treatment system modelling.

Zusammenfassung

DAS PROBLEM ABGEFAHRENEN FAHRZEUGE

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Die Einstellungen zur Lösung des Alokationsproblems und die Verteilung der Recyklingzentren für abgefahrene Fahrzeuge in Tschechischen Republik gehen von Zustand, voraussetzene Entwicklung und gedankte Zielstand aus. Der Zustand von Liqudierung abgefahrenen Fahrzeuge in CR ist nicht anregend. Der Artikel ist ein Beitrag zur Diskusion über Möglichkeiten der analytischen Lösungen von Verteilung Recyklingzentren und Modellierung des Liqudierungssystems der abgefahrenen PKW und LKW.