Staff Paper P19-3 **March 2019**

Staff Paper Series

A Multi-Period, Multiple Objective, Mixed Integer Programming, GAMS Model for Transit System Planning

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Abstract

This paper provides a detailed overview of a general mathematical programming model of transit system operations. The model is designed to address a wide range of transit planning and policy problems while considering a variety of managerial and public policy objectives. As a decision support tool for system managers, the model will provide optimal vehicle assignments and schedules given the available resources, market conditions and the demand for services. Strategic planning problems may be supported also, for example by solving the model with alternative fleet configurations, levels of service, market conditions and public policies. Policy analysts may use the model to predict how public policies might impact transit system management including costs of operation, necessary changes to fleet composition and other transit management issues. The model will derive optimal plans considering two or more performance measures and may be used to determine efficient trade-offs between alternative goals. Performance measures or objectives may be general, or time and/or location specific when appropriate. Integer variables are used to characterize discrete decisions such as the assignment of vehicles to routes over a set of operating periods and may include "deadheading" costs between depots and routes. Operating activities allow for the deployed vehicles to be used under various operating practices that may have different resource requirements, service contributions and/or performance measure consequences. An example analysis of bus scheduling using data from the Minneapolis-St Paul Metro Transit System is presented. In that study, daily bus scheduling plans are found considering total operating cost, CO_2, NO_X and particulate emissions, and a measure of emissions cost. The model is constructed using GAMS – the Generalized Algebraic Modeling System software -- and is designed to be used by researchers, analysts and managers familiar with GAMS to analyze a wide range of transit problems. The GAMS code for the model, including that for the Metro Transit study and associated data files, are available from the authors by request.

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Introduction

Mathematical programming models have been widely used in studies of the economics of public transit systems. The ways in which critical characteristics of transit systems may be captured in optimization models and how those models may be solved have been widely studied (reviews may be found in Ibarra-Rojas et al. and Visentini et al). This paper presents a general mathematical programming model of transit system operations. The multi-objective, multi-period, mixed integer programming model determines efficient transit vehicle assignments to transit routes considering various performance measures, such as operating cost and emissions. The objectives in the model may include performance measures such as certain emissions for which costs vary based on time and/or location. The demand for transit services may be set exogenously by setting fixed vehicle capacities and service frequencies. Or, if the benefits of system use may be represented by mathematical functions, optimal levels of service may be endogenous. Other elements of transit system management, such as inter-routing and deadheading, may also be included in the model to allow vehicles to switch routes and run non-service trips to increase the utilization of the fleet. The objective function may be specified as an over-arching function of several performance measures, or a subset of the performance measures may be optimized while others are fixed at targeted levels. The mathematical program is constructed with GAMS, the General Algebraic Modeling System, a widely used computer package for applied mathematical programming problems. The GAMS program, called TRANSIT-OP-V03, is written for use in analyses of a wide range of specific transit system problems.[2] The use of the model is demonstrated using bus data from the Metro Transit System in Minneapolis and Saint Paul.

The scheduling of transit system vehicles is a network planning problem in which the optimal assignment of vehicles to routes must be determined while meeting required levels of service. Traditionally, the vehicle scheduling problem has focused on minimizing the costs of vehicle operation and ownership while meeting service requirements. Transit models involving the deployment of vehicles from a single depot are common [Ibarra-Rojas et al., 2015]. Problems involving one depot and one type of vehicle are relatively easy to solve using solution techniques such as the quasi-assignment or auction algorithms [Freling et al., 2001; Bunte and Kliewer, 2009]. The multi-depot vehicle scheduling problem allows vehicles to be deployed from more than one location – solving such problems is more difficult [Ibarra-Rojas et al.]. Transit systems often have heterogeneous fleets with vehicle types that have different service capacities, and different fixed and variable costs. Bodin et al. (1983) and Costa et al. (1995) approach the multi-vehicle scheduling problem by dividing it into sub-problems for each vehicle type. In addition, Forbes et al. (1994) and Löbel (1997)

[2] The GAMS code for TRANSIT-OP-V03, including data files for the application discussed later in this paper, are available upon request from the authors. Direct inquiries to Jeffrey Apland, JApland@umn.edu.

present modeling frameworks that allow for restrictions on the assignment of particular vehicle types to specific routes given more than one depot.

Including common aspects of transit system operations, such as deadheading and inter-routing, make transit system planning models more realistic. Baita et al. (2000) present a model that includes dead-heading, refueling, and resting locations where vehicles may remain idle until needed. The authors minimize several objectives such as deadheading costs, fleet size and the number of routes to which a vehicle may be assigned. Banihashemi and Haghani (2000) use integer programming for a multiple-depot vehicle scheduling problem, with the objective of minimizing capital and deadheading costs. The model includes restrictions on route time to account for factors such as vehicle fuel capacity. Ceder (2011) proposes an approach to vehicle assignment problems with multiple vehicle types and route characteristics. They use a cost-flow network approach in which each trip is a node and arcs are used to connect sequentially-scheduled trips. The model minimizes operating and deadheading costs.

Increasingly, vehicle scheduling models address the environmental impacts of transit system operation. Dessouky et al. (2003) discuss how to combine routing and scheduling decisions in an optimization model where environmental outcomes are included in the objective function. Li and Head (2009) present a bus scheduling model that minimizes operating costs and emissions while constraining the budget for purchasing new buses and the specifying minimum levels of service. Figliozzi (2010) develops a vehicle routing model to minimize emissions and fuel consumption. Departure times and travel speeds are decision variables in the model. Emissions levels are a function of the vehicle speed to capture the effect of traffic congestion on vehicle emissions and fuel efficiency. Gouge et al. (2013) use nonlinear programming to optimize vehicle assignments, minimizing costs, health and climate effects. The climate impact is measured by the global warming commitment and the health effected is measured as PM2.5 exhaust emissions within 5,000 meters the routes. The authors explore how various bus technologies and the emissions exposure potentials can be used to improve vehicle assignments.

In the next section of the paper, a general mathematical programming model is presented, including references to the GAMS implementation of the model – TRANSIT-OP-V03. Following the presentation of the mathematical programming model, we discuss an application of TRANSIT-OP-V03 using bus fleet and route data from Metro Transit in Minneapolis and Saint Paul, Minnesota. GAMS program details and results from the Metro Transit problem are documented in the Appendix of the paper, which includes the output, or list file, for a run of the GAMS model.

The Mathematical Programming Model

In this section, we will present a mathematical programming, transit planning model. The model is stated algebraically in Figure 1. The multiple-objective, mixed integer, linear program finds the optimal assignments and operating practices for transit vehicles over multiple planning periods. Decision variables include vehicle scheduling and operating activities, input/resource use and purchase activities, service attribute levels, and vectors of general, and time- and zone-specific performance measures. The following sets characterize the dimensions of the problem's instruments and constraints:

θ_T: planning periods (t)
θ_S: operating schedules (s)
θ_R: routes (r)
θ_V: vehicle types (k)
θ_P: operating practices (j)
$\theta_{RV}(\theta_R,\theta_V)$: vehicle types mapped to routes (k)
$\theta_{VP}(\theta_V,\theta_P)$: practices mapped to bus types (j)
θ_I: inputs and resources (i)
θ_H: service/demand attributes (h)
θ_Z: geographic service zones (g)
θ_Q: performance measures (q)
$\theta_{QN}(\theta_Q)$: general performance measures (q)
$\theta_{QZ}(\theta_Q)$: time & zone specific performance measures (q)

Symbols corresponding to the parameter or variable index associated with the set in the algebraic model are in parentheses following each set description. Planning periods, set θ_T, are the discrete time periods over which resource availability and use, and service requirements are defined. For example, planning periods might be one hour periods over one or more days. An operating schedule is a sequence of consecutive time periods over which a vehicle may be assigned – a schedule could be initiated in several planning periods. Vehicle types, θ_V, are assigned to routes, θ_R, according to a schedule, θ_R, initiated in a particular planning period. Transit services are measured by various attributes θ_H. Optimal transit plans are derived according to a weighted sum of performance measure levels and or targeting levels of performance measures, which may be general, $\theta_{QN}(\theta_Q)$, or time or zone specific, $\theta_{QZ}(\theta_Q)$.

The sets above include multi-dimensional sets – they play an import role here and in the GAMS implementation of the model. θ_{RV} is a mapping of vehicles, set θ_V, to routes, set θ_R. Generally, all vehicles may be assigned to all routes. However, for technical reasons, it may be impossible to assign particular vehicles to some routes. Or, for policy reasons, specific vehicles may be excluded from some routes. For instance, it may be the policy that non-hybrid buses cannot be used on routes in certain geographic zones. Whether for technical reasons of because of operating policies, the implicit constraint of limiting a vehicle type to a subset of routes may be captured in the definition of these multi-dimensional or mapped sets. Similarly, some alternative operating practices, θ_P, may only be relevant for a subset of vehicles, θ_V, through mapped set $\theta_{VP}(\theta_V,\theta_P)$.

The decision variables in the model include the vehicle scheduling activities XS_{t_lsrk} which represent the number of vehicles of type k assigned to route r, by schedule s beginning in planning period t_l; vehicle

Figure 1: The Mixed Integer Programming Transit Planning Model.

Maximize:

$$F[Q] = \sum_{q\in\theta_{QN}} CQN_q QN_q + \sum_{t\in\theta_T}\sum_{z\in\theta_Z}\sum_{q\in\theta_{QZ}} CQZ_{tzq} QZ_{tzq}$$ [Objective Function, OBJECTIVE]

Subject to:

$$\sum_{t_l\in\theta_T}\sum_{s\in\theta_S}\sum_{r\in\theta_R}\sum_{k\in\theta_{RV}} AS_{t_l tsrki} XS_{t_l srk} + \sum_{r\in\theta_R}\sum_{k\in\theta_{RV}}\sum_{j\in\theta_{VP}} AO_{trkji} XO_{trkj} - V_{ti} = 0 \quad t\in\theta_T \quad i\in\theta_I$$ [Input Use Constraints, INPUT]*

$$\sum_{t_l\in\theta_T}\sum_{s\in\theta_S}\sum_{r\in\theta_R} AV_{t_l tsrk} XS_{t_l srk} \le BV_{tk} \quad t\in\theta_T \quad k\in\theta_V$$ [Vehicle Resource Constraints, VEHICLE]*

$$-\sum_{t_l\in\theta_T}\sum_{s\in\theta_S} AC_{t_l tsrk} XS_{t_l srk} + \sum_{j\in\theta_{VP}} XO_{trkj} = 0 \quad t\in\theta_T \quad r\in\theta_R \quad k\in\theta_{RV}$$ [Operating Capacity Constraints, OPCAP]*

$$\sum_{t_l\in\theta_T}\sum_{s\in\theta_S}\sum_{k\in\theta_{RV}} ES_{t_l tsrkh} XS_{t_l srk} + \sum_{k\in\theta_{RV}}\sum_{j\in\theta_{VP}} EO_{trkjh} XO_{trkj} - Y_{trh} = 0 \quad t\in\theta_T \quad r\in\theta_R \quad h\in\theta_H$$ [Transit Service Attributes, SERVICE]*

$$\sum_{t\in\theta_T}\sum_{t_l\in\theta_T}\sum_{s\in\theta_s}\sum_{r\in\theta_R}\sum_{k\in\theta_{RV}} CNS_{tt_l srkq} XS_{t_l srk} + \sum_{t\in\theta_T}\sum_{r\in\theta_R}\sum_{k\in\theta_{VB}}\sum_{j\in\theta_{VP}} CNO_{trkjq} XO_{trkj}$$
$$+ \sum_{t\in\theta_T}\sum_{i\in\theta_I} CNV_{tiq} V_{ti} + \sum_{t\in\theta_T}\sum_{r\in\theta_R}\sum_{h\in\theta_H} CNY_{trhq} Y_{trh} - QN_q = 0 \quad q\in\theta_{QN}$$ [General Performance Measure Equations, PERFG]*

$$\sum_{t_l\in\theta_T}\sum_{s\in\theta_S}\sum_{r\in\theta_R}\sum_{k\in\theta_{RV}} CZS_{t_l srkzq} XS_{t_l srk} + \sum_{r\in\theta_R}\sum_{k\in\theta_{RV}}\sum_{j\in\theta_{VP}} CZO_{trkjzq} XO_{trkj} - QZ_{tzq} = 0 \quad t\in\theta_t \quad z\in\theta_Z \quad q\in\theta_{QZ}$$ [Time & Zone Specific Performance Measure Equations, PERFTZ]*

$XS, XO \ge 0$; XS Integer; $\overline{V}_{min} \le V \le \overline{V}_{max}$; $\overline{Y}_{min} \le Y \le \overline{Y}_{max}$; $\overline{QN}_{min} \le QN \le \overline{QN}_{max}$; $\overline{QZ}_{min} \le QZ \le \overline{QZ}_{max}$ [Variable Bounds]

* The portions of the objective and constraint function descriptions in all capital letters are the corresponding equation labels in the GAMS program.

operating activity XO_{trkj}, the hours of operation for vehicle type k on route r, by operating practice j, in period t; V_{ti} the quantity purchased or supplied of input k in period t; Y_{trh} is the level of service/demand attribute h on route r in period t. Finally, QN_q is the level of general performance measure q, and QZ_{tzq} is the level of time and zone specific performance measure q in period t and zone z.

Scheduling activities XS capture the assignment of vehicles to routes. These activities begin in a particular planning period t_l, the first period of the schedule, and continue over a number of subsequent planning periods. Since assigning a vehicle to a particular route on a specific schedule is a discrete decision, XS are integer variables. Other assignment-related decisions may also be represented with elements of XS. For example, if the transit system includes light rail, scheduling activities may be used to assemble trains for use in particular planning periods. The scheduling variables use inputs including vehicle resources and provide capacity used by operating activities XO_{trkj}. XO are continuous variables and represent the operation of vehicles of type k, by operating practice j, on route r in planning period t. Vehicles may be operated in different ways with alternative operating practices which have different resource requirements, service attributes, and/or performance results. Parameter $AS_{t_l tsrki}$ is the net requirement of input i in period t associated with the assignment of bus type k to route r on schedule s beginning in period t_l. AO_{trkji} is the net requirement of input i in period t associated with operating bus type k on route r using operating practice j. So, the total net use of input i in period t by scheduling activities XS and operating activities XO is:

$$\sum_{t_l \in \theta_T} \sum_{s \in \theta_S} \sum_{r \in \theta_R} \sum_{k \in \theta_{RV}} AS_{t_l tsrki} XS_{t_l srk} + \sum_{r \in \theta_R} \sum_{k \in \theta_{RV}} \sum_{j \in \theta_{VP}} AO_{trkji} XO_{trkj}$$

Since the purchase or supply activity for an input, V_{ti}, is subtracted and the equation is set equal to zero, the input use constraint requires the quantity purchased or supplied to be equal to use. When operating inputs (for example, fuel) are available in infinitely elastic supply, the purchasing activity will contribute to total operating cost through the appropriate performance measures. In this case, the lower bound is zero and there is no upper bound. The availability of a fixed resource would be the upper bound on the corresponding variable V_{ti}. If needed in a particular planning problem, positive lower bounds may be assigned. Vehicle types, set θ_V, play a unique role in the model. A vehicle resource constraint for each vehicle type and period limits the assignment of vehicles in each period to no more than the number in the fleet. $AV_{t_l tsrk}$ is the vehicle requirement for bus type k on route r in period t, for schedule s initiated in period t_l. The operating capacity constraints set limits on the operating activities for bus type k on route r in period t, summed over all operating practices j, to the total number of hours allocated through the scheduling activities.

To illustrate the workings of the scheduling activities, a partial tableau of the model is presented in Table 1. This example shows four schedules of one, two, three and four periods of operation, respectively, on a specific route r for bus type i. For purposes of this example, each schedule is initiated in period one or period two. The constraint sets include the number of available buses of type i by period, hours operating capacity for type i buses by period, and constraints for an operating input by period. With four schedules beginning in periods one and two, there are a total of eight integer, scheduling activities XS. XS is the

Table 1: Partial Tableau Illustrating the Relationship between Scheduling Variables and Operating Activities.

	XS_{11rk}	XS_{12rk}	XS_{13rk}	XS_{14rk}	XS_{21rk}	XS_{22rk}	XS_{23rk}	XS_{24rk}	XO_{2rk1}	XO_{3rk1}	XO_{4rk1}	XO_{5rk1}	XO_{6rk1}	XO_{2rk2}	XO_{3rk2}	XO_{4rk2}	XO_{5rk2}	XO_{6rk2}	V_i	RHS
Input Use Constraint																				
Diesel Fuel*	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-1	= 0
Vehicle Constraints																				
Vehicles, Type k, Period 1	+	+	+	+																≤ +
Vehicles, Type k, Period 2	1	1	1	1	+	+	+	+												≤ +
Vehicles, Type k, Period 3	+	1	1	1	1	1	1	1												≤ +
Vehicles, Type k, Period 4		+	1	1	+	1	1	1												≤ +
Vehicles, Type k, Period 5			+	1		+	1	1												≤ +
Vehicles, Type k, Period 6				+			+	1												≤ +
Vehicles, Type k, Period 7								+												≤ +
Operating Capacity Constraints																				
Vehicle Type k, Route r, Period 2	-	-	-	-					1					1						≤ 0
Vehicle Type k, Route r, Period 3		-	-	-	-	-	-	-		1					1					≤ 0
Vehicle Type k, Route r, Period 4			-	-		-	-	-			1					1				≤ 0
Vehicle Type k, Route r, Period 5				-			-	-				1					1			≤ 0
Vehicle Type k, Route r, Period 6								-					1					1		≤ 0
Lower Bound	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Upper Bound	+	+	+	+	+	+	+	+	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	

XS Integer

* Diesel fuel is used here to illustrate an input constraint. To save space here, this input constraint is not shown over time periods. The units of the scheduling activities, XS, are vehicles assigned and the coefficients on the diesel constraint are the fuel requirements for deadheading to and from the route in the appropriate planning periods. Units of the operating activities are hours, so the fuel constraint coefficients are gallons per hour in the period of operation.

number of buses deployed on that schedule beginning in a particular period – an integer decision variable. Activities XO represent the total hours of operation of bus type i, by operating practice j, on route r in period t. In this example, there is only one bus type, one operating mode, and one route. Activities V represent purchases of operating input k by period – for example, diesel fuel. The bus constraints limit the scheduling of buses by type and period to no more than the number of buses of that type available – the righthand sides of the constraints. Schedules 1, 2, 3 and 4 assign the buses for use on the route for 1, 2, 3 and 4 operating periods, respectively. When schedule 1 is initiated in period 1, "deadheading", or driving the bus from the depot to the route and back, occurs in periods one and three, respectively. The bus is in service in period two and one bus is required (AS_{211rki}=1.0 (here, k is the resource, buses)). The constraint coefficients for periods one and three represent the portion of the periods required for deadheading to the route and back to the depot, respectively. This pattern repeats for schedules 2, 3 and 4. For example, for each bus using schedule 4 beginning in period 1, one bus is used in each of periods 2 through 5, and a proportion of a bus is used in periods 1 and 6 for deadheading. By using only a portion of the period before and after the service periods, the scheduling activities allow for the possibility of a bus returning from one route to be rescheduled in the same period when time permits. For the scheduling activities initiated in period 2, the coefficients are shifted ahead by one operating period.

Bus operating capacity is provided by the scheduling activities and used by the operating activities. In the operating capacity constraints, the negative coefficients represent minus the hours of operating time per period and occurs in all periods for which the bus is scheduled to operate. Operating activities XO are measured in bus hours and each requires 1 hour of capacity in the period of operation. By these constraints, then, the total use of operating capacity for a particular route and bus type cannot exceed the hours allocated through the scheduling activities.

Operating inputs, such as diesel fuel, are used by the scheduling activities for deadheading, and by the operating activities. The positive coefficients on the scheduling activities represent the fuel required per bus for deadheading to the route in the first period of the schedule, and for deadheading back to the depot in the last period. The operating activities use fuel in the period of operation, so the positive coefficients represent fuel consumption per bus and per hour of operation. In each period, operating input use minus the quantity purchased must equal zero, or purchases must equal use. Recall that in general, a bus could be operated in multiple modes with different input requirements, service coefficients, and/or performance measure coefficients.

The contributions of scheduling and operating activities to service attributes are elements of parameters ES and EO. $ES_{t_l tsrkh}$ is the level of service attribute h in planning period t per unit of the assignment activity for vehicle type k, route r, and schedule s initiated in period t_l. EO_{trkjh} is the level of service attribute h in period t per unit of the operating activity for bus type k on route r using operating practice j in period t. A service attribute constraint defines the level of service attribute h on route r in period t, Y_{trh}. Examples of service attributes might be the total number of buses to achieve a desired service frequency or total bus capacity for a route. Minimum service levels may be set as lower bounds on Y_{trh} ($\overline{Y}_{min,trh}$). Alternatively, a performance measure could be used to capture the benefits of transit service, which would be determined endogenously.

The levels of the performance measure variables QN_q (general) and QZ_{tzq} (time- and zone- specific) are defined by the performance measure constraints. Performance measures are expressed here as linear functions of the scheduling and operation activities, and input use and service attributes variables. Performance measures for a transit system might include operating costs and the levels of various bus emissions. Time- and zone-specific performance measures should be used when the performance measures vary by time and location. For instance, the health effects of particulate emissions depend on the timing and location of the emissions. The per unit contributions of scheduling, operation, input use and service variables to the performance measures are $CS_{t_l srkq}$, CO_{trkjq}, CV_{tiq} and CY_{trhq}. One approach to multiple objective programming is to maximize or minimize an overall objective function of the vectors of performance measures. This is the approach used here, which is to maximize the overall objective F(Q), a linear function of the performance measures with coefficient CQN_q the weight for performance measure Q_q and CQZ_{tzq} the weight on QZ_{tzq}. Another approach to the analysis of problems with multiple goals is to constraint the levels of all but one or a proper subset of the performance measures and to optimize a the unconstrained measure or a function of the unconstrained measures. This alternative could be used by setting finite bounds for the performance measures – shown in the algebraic model as parameters $\overline{QN}_{min}$, $\overline{QN}_{max}$, $\overline{QZ}_{min}$ and $\overline{QZ}_{max}$. Details of alternative multiple objective or goal programming approaches are discussed at the end of this section.

As mentioned earlier, the multiple objective or goal programming framework is facilitated in the model through the inclusion of performance measures that are general, QN_q, or time- and/or zone-specific, QZ_{tzq}. For example, consider a planning problem with operating cost and emissions as performance measures. Figure 2 shows a feasible set of operating cost and emissions combinations for a hypothetical transit planning problem. The bold boundary line shown represents the efficient frontier – the schedules and operating activity levels associated with each point on the frontier are efficient in that it is not possible to reduce emissions without increasing operating costs, and visa-versa. The mathematical programming model is designed to reveal this frontier – efficient solutions from which to choose an optimal solution or perhaps to determine the optimal plan based on a global objective.[3]

As stated in Figure 1, the objective function is a linear function of the performance measures. The objective function could be nonlinear. For example, it may be appropriate to use a function for which the marginal penalty on emissions increases as the level of emissions increases. However, for discussion purposes here, we will assume a linear objective. Figure 3 includes objective function contours, preference directions and optimal solutions for three cases. Weights on operating costs and emissions would be negative, or

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[3] The algebraic model is a mixed integer linear program. As a linear program, the efficient frontier would be piecewise linear. For a problem with many decision variables and constraints, the frontier may appear to be smooth. Because of the discrete choice variables, the frontier will include segments that are non-convex. For a discussion of efficient frontiers in mixed integer programming, see [Jobst, et al.].

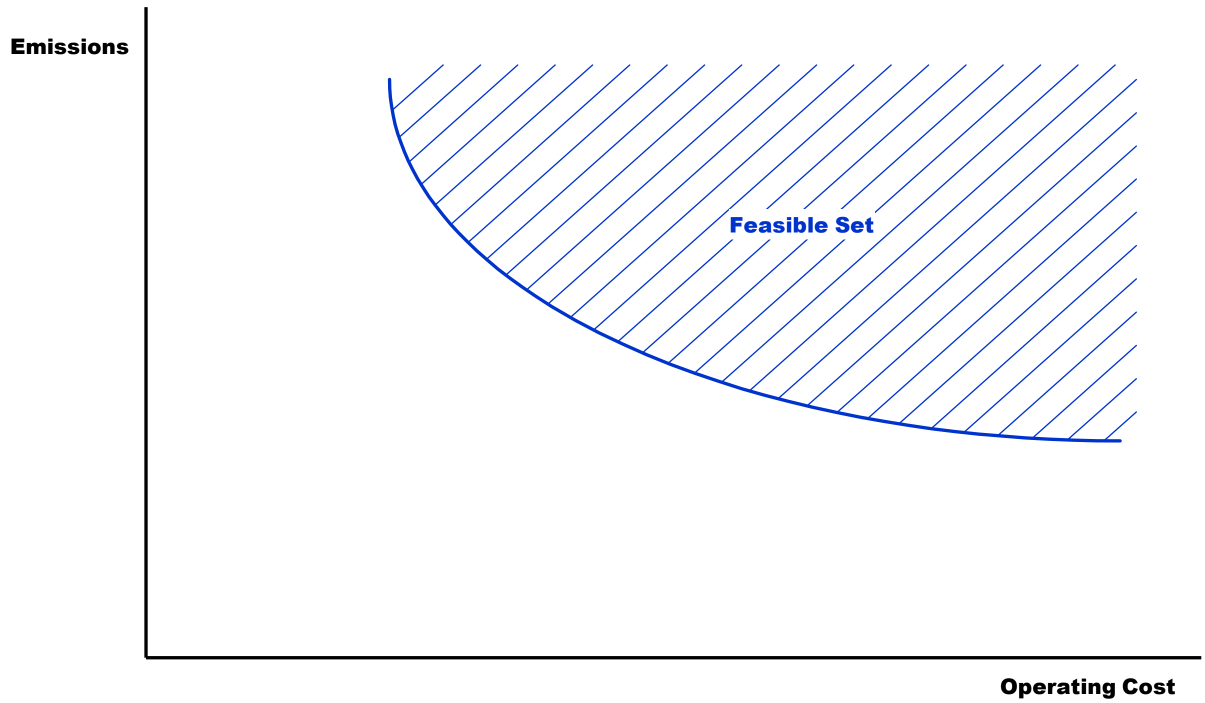

Figure 2: Feasible and Efficient Operating Cost and Emissions Combinations.

equivalently, the weights could be positive and the objective minimized. To minimize operating cost, weights on cost and emissions are set to 1.0 and 0.0, respectively. The objective function contour is vertical, the preference direction is to the left, and the optimal transit plan occurs at point A. To minimize emissions, the weights on cost and emissions are 0.0 and 1.0, the objective function contour is horizontal, the preference direction is down and the optimal plan is at point B. These two solutions reveal the endpoints of the efficient frontier for operating cost and emissions. If both operating cost and emissions are to be penalized, say with weights of 1.0 on cost and α on emissions, the contour has a negative slope (specifically -1/α) as illustrated by the third contour in Figure 3. The preference direction is southwest, and the optimal plan is at point C – an intermediate point on the frontier. By increasing α from zero in small increments, several efficient plans characterizing the efficient frontiers are revealed. As discussed in , the frontier in the case of mixed integer programming model has non-convex segments, which the solver would skip. It should be noted that a typical transit planning problem would have a very large number of discrete scheduling variables, with many vehicle type, routes and schedules possible. As a result, alternative mixed integer programming solutions for typical planning problems will allow for small adjustments in the performance measures.

Figure 4 illustrates another common approach to multiple goal planning problems. Here, an upper bound is set on emissions and operating cost is minimized. As before, the objective function contour is vertical and the preference direction is left. The upper bound on emissions forces operating costs to be greater than before when emissions were unrestricted – point A in Figure 3. Solutions along the efficient frontier are revealed by solving the model with various limits on emissions over the relevant range.

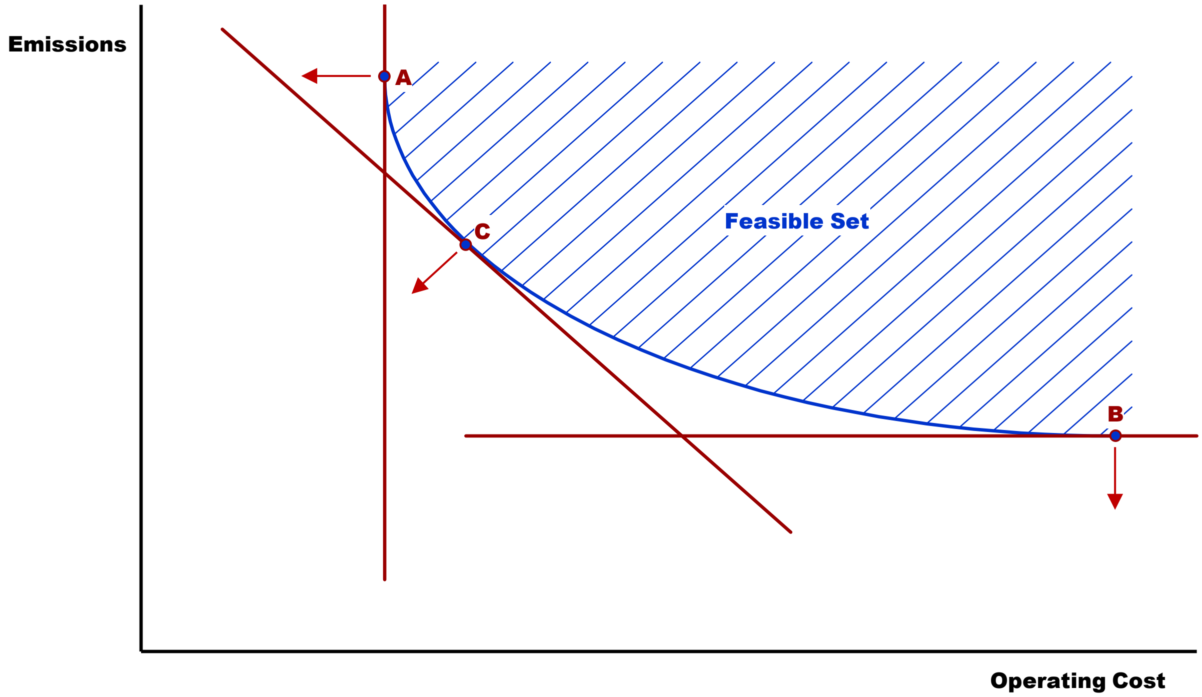

Figure 3: Optimal Transit Plans Given Different Weights on Cost and Emissions.

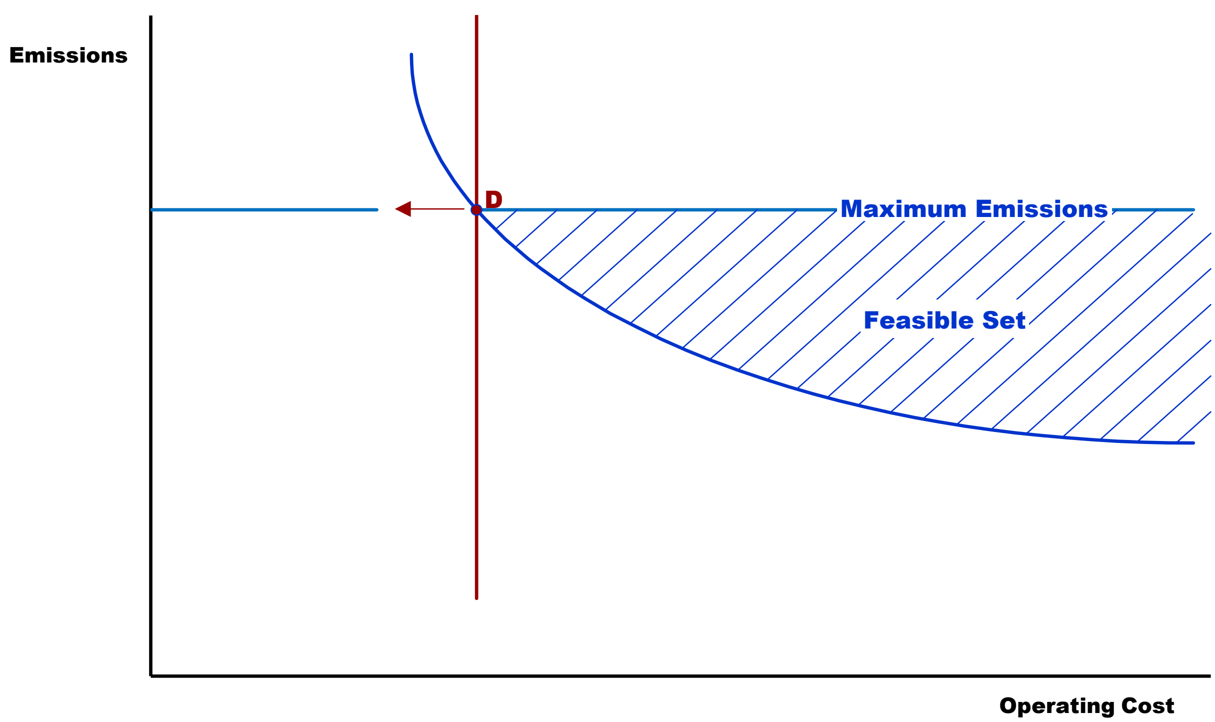

Figure 4: Cost Minimization Subject to an Upper Limit on Emissions.

An Application to the Minneapolis-St. Paul Metro Transit System

Output for a representative application of the transit model appears in the appendix. General details of this application will be discussed here. Further details of the Metro Transit study can be found in Sun [2015] and Sun and Apland [2019]. Metro Transit operates the public bus system in the Minneapolis-Saint Paul metropolitan area. In 2013, the system had 912 buses with service on 128 routes. Of these, 60 were urban, local routes, 60 were express routes, and six were suburban, local routes. Metro Transit also operates two light rail routes and a commuter rail line. The study provides technical and economic data, and demand levels for a subset of Metro Transit routes – the model includes these routes for a hypothetical transit planning problem. The Metro Transit problem involves 23 routes, 10 types of buses, and a total of 271 buses. The planning horizon is one day, divided into 22 planning periods one hour in length. Bus service occurs from 5 am to 1 am – an addition planning period before and after the periods of service are added to allow for deadheading.

Operating costs are based on consumption levels by bus type and route, market prices for fuel and maintenance cost records provided by the technical support group at Metro Transit. Bus types are defined based on the size and manufacturer of the engine, passenger capacity and the year in which emissions were certified. The year of emission certification is usually the same as the model year of the bus, but there are a few exceptions. For example, some articulated and coach buses are equipped with older emission certified engines than the model year implies. Hybrid-electric buses are equipped with 6.7 liter engines, while standard diesel, coach and articulated buses usually have 8.9 or 10.8 liter engines. Service requirements in the study are based on frequency and total seat capacity for each route in each planning period. Service requirements by route are based on actual levels of service from the Automatic People Counting system. Trip frequency is based on the actual number of trips scheduled by Metro Transit. For this study, five performance measures are used and optimized allow or as part of a joint objective function. The performance measures include operating cost, CO_2, NO_X, particulates, and emissions cost. Emissions cost is based on social costs estimated by Goodkind and Polasky [2013] for CO_2, NO_X and particulate emissions – a weighted sum of the emissions levels where these prices are the weights. If the objective function weight (CQN_q) on operating cost and emissions cost are both set to -1.0 (when minimizing the objective function), the estimated values are used a costs for the component emissions. Values less than or greater than -1.0 on the emissions cost objective function coefficient, then, represent proportional increases or decreases, respectively, on the individual emissions prices, with the relative weights on CO_2, NO_X and particulates remain those implied by the prices on those emissions.

The baseline solution of the model for the Metro Transit problem is the optimal solution when minimizing operating cost – the weight on operating cost is -1.0 in the maximization problem. The output or list file for this run appears in the appendix. Symbol listings are included in this run, so interested readers may find various sets, parameters and variables in the program listing. To a large extent, labels in the GAMS code are the same or similar to those used in the algebraic model (see Figure 1). The GAMS model is solved with the CPLEX mixed integer, linear programming solver. For this problem, the model has 54,443 variables, including 48,300 discrete variables, and 6,363 constraints. Details of the optimal solution may be found in the output file in the appendix. Some results for the baseline solution (run 1) will be reported here, along with those from three other solutions. The other solutions include the minimum emissions cost solution (run 2), and the solution minimizing total cost, defined as the sum of operating and emissions costs (run 3). Finally, the model is solved to minimize operating cost with an upper bound on NO_X – specifically, NO_X is limited to 50% of the level associated with the operating cost minimizing solution.

Performance measures for each of the four solutions are reported in Table 2. The minimum operating cost solution has an operating cost of $14,216. Emissions levels for this solution are 37,900 kilograms CO_2, 84.76 kilograms of NO_X, and 733.20 grams of particulates. These emissions levels yield an emissions cost of $1,852 for a total cost of $16,068. The performance measure values are given in Table 2 for the other three solutions also – the percentage level in parentheses below each result is the percent change in that performance measure from the operating cost minimizing solution. When emissions cost is minimized, emissions cost declines by 3.78% to $1,782, while operating cost increases by 1.86%. The reduction in emissions cost comes from a 32.09% decline in NO_X emissions, despite a 1.68% increase in CO_2 and a slight increase in particulates of 0.02%. When total cost is minimized (run 3), operating cost and emissions costs both fall between their values for runs 1 and 2, as would be expected. Relative to the results for the baseline solution, NO_X declines by 8.18%, particulates decline slightly by 0.07%, and CO_2 increases slightly by 0.02%. Operating costs increase slightly (0.08%) and emissions costs go down by 1.30% relative to the baseline solution.[4] More details for runs 1 and 3 are provided in Table 3. The table shows the total optimaloperating hours for each type of bus on each route and on all routes, for the minimum operating cost (run 1) and minimum total cost (run 3) solutions. Shown, too, is the change in hours of operation for each bus type on each route, and the change in total hours of operation for each bus type. For this problem,

Table 2: Performance Measure Results with Different Objectives.

		Performance Measure Values					
Run	Objective	Operating Cost ($/day)	Emissions Cost ($/day)	Total Cost ($/day)	CO_2 Emissions (kg/day)	NO_X Emissions (kg/day)	PM Emissions (g/day)
1	Operating Cost	14,215.6	1,852.1	16,067.7	37,900.2	84.76	733.20
2	Emissions Cost	14,479.4 (1.86%)	1,782.0 (-3.78%)	16,261.4 (1.21%)	38,536.6 (1.68%)	57.56 (-32.09%)	733.31 (0.02%)
3	Total Cost	14,227.2 (0.08%)	1,828.1 (-1.30%)	16,055.3 (-0.08%)	37,906.9 (0.02%)	77.83 (-8.18%)	732.72 (-0.07%)
4	Operating Cost with NO_X Constraint	15,185.1 (6.82%)	1,807.2 (-2.42%)	16,992.4 (5.76%)	40,488.3 (6.83%)	42.00 (-50.45%)	775.20 (5.73%)

[4] Note that runs 1, 2 and 3 correspond intuitively with solution A, B and C in Figure 3. For solution B, a weighted combination of operating cost and emissions is minimized. For run 3, operating cost and emissions cost both have weights of 1 (or -1 as a maximization problem).

Table 3: Optimal Hours of Bus Operation When Minimizing Operating Cost and Minimizing Operating Plus Emissions Cost, Route by Bus Type.

	Optimal Operating Hours by Bus Type When Minimizing Operating Cost, Run 1										Optimal Operating Hours by Bus Type When Minimizing Operating Plus Emissions Cost, Run 3										Change in Optimal Operating Hours by Bus Type									
Route	B06	B14	B15	B16	B17	B21	B22	B23	B26	B28	B06	B14	B15	B16	B17	B21	B22	B23	B26	B28	B06	B14	B15	B16	B17	B21	B22	B23	B26	B28
R003			87							9			87							9										
R004			70			18							62			26							-8			8				
R005						124	1									124	1													
R007			18			20				1			18			20				1										
R009			45										44							1			-1							1
R010			11			21		61					51			22		20					40			1		-41		
R014						62										62														
R016	1		34			10	4			6	1		35			7	4			8			1			-3				2
R018										129										129										
R019						56				40						39				57						-17				17
R022						62										62														
R025			5	7		10							5	3		14								-4		4				
R050		2		16								2								16				-16						16
R061			39										38							1			-1							1
R094								37	20									42	15									5	-5	
R250					45		11								41		11		4						-4				4	
R649				11										11																
R652			6										6																	
R667								20										20												
R672								10										10												
R674			6										4			2							-2			2				
R675	1					29					1					29														
R766				37										37																
Total Hours	2	2	321	71	45	412	16	128	20	185	2	2	350	51	41	407	16	92	19	222			29	-20	-4	-5	0	-36	-1	37

service requirements are defined as minimum frequencies and minimum total capacity. Total operating hours does not change across solutions. The impact of addressing emissions cost, as reflected in operating hours, is to change 102 out of a total of 1,202 hours of operation, or 8.5% of the operating activities. Five different bus types are used less, and two bus types are used more.

For run 4, operating cost is minimized with maximum NO_X set at 50% less than in the baseline run. Recall that the NO_X level for the minimum operating cost plan was 84.760 kilograms. So, for run 4, an upper bound of 42.380 was imposed on NO_X. Notably, the optimal level of NO_X is less than the maximum level. This occurs due to the nature of mixed integer programming problems – the NO_X constraint is binding in the sense that increasing the upper bound on NO_X will eventually allow operating cost to decline. Relative to the baseline run, operating cost is 6.82% greater, emissions cost is 2.42% lower and total cost is 5.76% greater. Both CO_2 and particulates increase, by 6.83% and 5.73%, respectively. As noted before, the actual decline in NO_X is greater than the required 50% decrease – 50.45%. Table 4 shows operating hours for the baseline solution and for the solution with the NOX constraint, and the changes in hours of operation by bus type and route, and the totals by bus type. Significant changes occur between the two solutions – 740 operating hours change, or 61.6% of the total hours of operation on all routes.

Summary

This paper documents a GAMS mathematical programming model designed to analyze a wide range of transit system management and policy questions. The model allows for multiple, discrete planning periods, modes, vehicle types and depots. Multiple objectives may be considered through the use of performance measures, each of which may be general, time specific, location specific, or both time and location specific. The mathematical program uses integer variables for the assignment of vehicles to routes according to various schedules defined by the initial period of deployment and the duration of the assignment. Use of the model is demonstrated using Metro Transit data from Minneapolis and Saint Paul. Details of the GAMS program, called TRANSIT-OP-V03.gms, are presented. The GAMS model is available to interested GAMS users upon request.

Table 4: Optimal Hours of Bus Operation When Minimizing Operating Cost and Minimizing Operating Cost with a Constraint on NO_X*, Route by Bus Type.

Route	Optimal Operating Hours by Bus Type When Minimizing Operating Cost, Run 1										Optimal Operating Hours by Bus Type When Minimizing Operating Cost with NOX Constraint, Run 4										Change in Optimal Operating Hours by Bus Type									
	B06	B14	B15	B16	B17	B21	B22	B23	B26	B28	B06	B14	B15	B16	B17	B21	B22	B23	B26	B28	B06	B14	B15	B16	B17	B21	B22	B23	B26	B28
R003			87							9			12							84			-75							75
R004			70			18							85							3			15			-18				3
R005						124	1						124				1						124			-124				
R007			18			20				1										39			-18			-20				38
R009			45										39							6			-6							6
R010			11			21		61												93			-11			-21		-61		93
R014						62							1							61			1			-62				61
R016	1		34			10	4			6			1				4			51	-1		-33			-10				45
R018										129										129										
R019						56				40										96						-56				56
R022						62														62						-62				62
R025			5	7		10							19							3			14	-7		-10				3
R050		2		16								2								16				-16						16
R061			39										33							6			-6							6
R094								37	20										3	54								-37	-17	54
R250					45		11								37		11		8						-8				8	
R649				11									11										11	-11						
R652			6										6																	
R667								20										20												
R672								10								10										10		-10		
R674			6										2			4							-4			4				
R675	1					29							27							4	-1		27			-29				4
R766				37										33					4					-4					4	
Total Hours	2	2	321	71	45	412	16	128	20	185		2	360	33	37	14	16	20	15	707	-2		39	-38	-8	-398		-108	-5	522

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This appendix has the output or lst file for a representative run of TRANSIT-OP-V03 with data for the Metro Transit problem discussed in the paper. The GAMS code and associated data files for this application are available from the authors upon request. For this run, operating cost plus emissions cost is minimized – a solution discussed earlier in the paper.

Appendix Table of Contents: TRANSIT-OP-V03 List File.

```
GAMS 25.1.3  r4e34d435fbd Released Oct 30, 2018 WEX-WEI x86 64bit/MS Windows  03/01/19 11:08:37 Page 1
TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
SELECT GENERAL OPTIONS AND DECLARE AND DEFINE SETS


* TRANSIT-OP-V03 IS A MULTI-PERIOD, MULTIPLE OBJECTIVE, MIXED INTEGER PROGRAMMING MODEL
* DESIGNED FOR DECISION SUPPORT AND ANALYSIS OF TRANSIT SYSTEM PLANNING PROBLEM
*
* JEFFREY APLAND AND BIXUAN SUN
* DEPARTMENT OF APPLIED ECONOMICS
* UNIVERSITY OF MINNESOTA


OPTION LIMROW=0, LIMCOL=0, SOLPRINT=OFF, RESLIM=1200, OPTCA=0.00, OPTCR=0.0001;


* SET JRTBL AND PARAMETER PRNT CONTROL THE DISPLAY OF OPTIMAL SOLUTION REPORTS

SET JRTBL RESULTS TABLES
 /01  GENERAL PERFORMANCE MEASURE ACTIVITY RESULTS,
  02  TIME & ZONE SPECIFIC PERF MEASURE ACTIVITY RESULTS,
  03  TIME & ZONE SPECIFIC PERF MEASURE ACTIVITIES - TOTALS,
  04  SCHEDULING ACTIVITY RESULTS,
  05  VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE,
  06  VEHICLE OPERATING ACTIVITIES FOR EACH VEHICLE,
  07  VEHICLE OPERATING ACTIVITIES ON ALL ROUTES,
  08  INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITIES AND BOUNDS,
  09  INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITIES,
  10  SERVICE OR DEMAND ATTRIBUTE LEVELS/;

* PRINT TABLE IF PRNT=1

PARAMETER PRNT(JRTBL) PRINT CONTROL  /01*09 1, 10 1/;


* OVERVIEW OF SETS USED IN THE MODEL
*------------------------------------------------------------------------------------------
* SET.............  DESCRIPTION.........................................................
*------------------------------------------------------------------------------------------
* JT                PLANNING PERIODS
* JT2               PLANNING PERIODS ALIAS OF JT
* JS                OPERATING SCHEDULES
* JTS               PERIODS OF OPERATION FOR SCHEDULES
* JR                ROUTES
* JRS(JR,JS)        SCHEDULES MAPPED TO ROUTES
* JV                VEHICLE TYPES
* JRV(JR,JV)        VEHICLE TYPES MAPPED TO ROUTES
* JP                OPERATING PRACTICES
* JVM(JV,JP)        OPERATING PRACTICES MAPPED TO VEHICLE TYPES
* JTSR(JT,JS,JR,JV) VEHICLE TYPES & ROUTES MAPPED TO OP SCHEDULES & INITIAL ASSIGN PERIOD
* JI                INPUTS AND RESOURCES
* JH                SERVICE OR DEMAND ATTRIBUTES
* JZ                GEOGRAPHIC SERVICE ZONES
* JQ                PERFORMANCE MEASURES
* JQN(JQ)           GENERAL PERFORMANCE MEASURES
* JQZ(JQ)           TIME AND ZONE SPECIFIC PERFORMANCE MEASURES
* JAC               ACTIVITY PARAMETERS
* JVC               VEHICLE PARAMETERS
* JRC               ROUTE PARAMETERS
* JRTBL             RESULTS TABLES
* JRTH              RESULTS TABLE HEADERS
*------------------------------------------------------------------------------------------
```

```
GAMS 25.1.3  r4e34d435fbd Released Oct 30, 2018 WEX-WEI x86 64bit/MS Windows  03/01/19 11:08:37 Page 2
TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
SELECT GENERAL OPTIONS AND DECLARE AND DEFINE SETS


* DISCRETE TIME PERIODS PLAY AN IMPORTANT ROLE IN THE MODEL AND ITS CONSTRUCTION.
* "PLANNING PERIODS", SET JT, REFER TO SPECIFIC TIME PERIODS DURING WHICH A VEHICLE MAY
* OPERATE, FOR EXAMPLE 8AM TO 9PM ON A PARTICULAR DAY.  AN "OPERATING SCHEDULE", SET JS,
* MAY INVOLVE OPERATION OF A VEHICLE, INCLUDING DEADHEADING AND SERVICE, IN ONE OR MORE
* PLANNING PERIODS.  "PERIODS OF OPERATION", SET JTS, REFER TO TIME PERIODS WITHIN
* SCHEDULES.  EACH SCHEDULE MAY BEGIN ON SEVERAL PLANNING PERIODS.

SET JT  PLANNING PERIODS  /T04*T09, T10*T25/;
* FOR THIS PROBLEM, BUS SERVICE BEGINS AT 5 AM AND CONTINUES UNTIL 1 AM.  PLANNING PERIODS
* ARE ONE HOUR IN LENGTH.  THE NUMBERS IN THE JS LABELS INDICATE THE HOUR THE PERIOD
* BEGINS.  AN ADDITIONAL PERIOD IS ADDED BEFORE 5 AM AND AFTER 1 AM DURING WHICH ONLY
* DEADHEADING OCCURS.  THE LAST PERIOD, T25, IS 1 TO 2 AM, WHEN ONLY DEADHEADING OCCURS.

  ALIAS(JT2,JT);


SET JS  OPERATING SCHEDULES  /OS01*OS09, OS10*OS20/;
* THE NUMBERS IN THE OPERATING SCHEDULE LABELS INDICATE THE NUMBER OF PERIODS THE VEHICLE
* WOULD BE IN SERVICE UNDER THAT SCHEDULE.  DEADHEADING IS ASSUMED TO OCCUR IN THE PERIOD
* BEFORE AND THE PERIOD AFTER THE PERIODS IN SERVICE FOR THE CURRENT APPLICATION.


SET JTS  PERIODS OF OPERATION  /TS01*TS09, TS10*TS22/;


SET JR  ROUTES  /R003, R004, R005, R007, R009, R010, R014, R016, R018, R019, R022, R025,
                 R050, R061, R094, R250, R649, R652, R667, R672, R674, R675, R766/;


SET JRS(JR,JS)  SCHEDULES MAPPED TO ROUTES;

  JRS(JR,JS) = YES;


SET JV  VEHICLE TYPES  /B06, B14, B15, B16, B17, B21, B22, B23, B26, B28/;


SET JRV(JR,JV)  VEHICLE TYPES MAPPED TO ROUTES;

  JRV(JR,JV) = YES;

* SOME VEHICLE TYPES MAY BE REMOVED FROM SPECIFIC ROUTES CONSIDERING ROUTE REQUIREMENTS
* AND CHARACTERISTICS OF THE VEHICLE.


SET JP  OPERATING PRACTICES  /BASE/;


SET JVM(JV,JP)  OPERATING PRACTICES MAPPED TO VEHICLE TYPES;

  JVM(JV,JP)=YES;


SET JTSR(JT,JS,JR,JV) VEHICLE TYPES ROUTES & OP SCHEDULES MAPPED TO INITIAL PERIODS;

  JTSR(JT,JS,JR,JV) = NO;

* JTSR WILL BE MAPPED DYNAMICALLY BASED ON THE MAPPINGS OF VEHICLE TYPES AND ROUTES TO
* SCHEDULES AND THE DURRATION OF THE SCHEDULE
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GAMS 25.1.3  r4e34d435fbd Released Oct 30, 2018 WEX-WEI x86 64bit/MS Windows  03/01/19 11:08:37 Page 3
TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
SELECT GENERAL OPTIONS AND DECLARE AND DEFINE SETS


SET JI  INPUTS AND RESOURCES  /DIESEL   DIESEL FUEL USAGE GAL,
                               MAINT    MAINTENANCE COST $/;

SET JH  SERVICE OR DEMAND ATTRIBUTES  /TSEAT  TOTAL CAP FOR RTE - SEATS ON ALL VEHICLES,
                                       FREQ   MIN FREQUENCY OR VEHICLE HOURS/;

SET JZ  GEOGRAPHIC SERVICE ZONES  /MAIN/;

* ZONES ARE NOT YET FULLY INCORPORATED INTO THE CALCULATION OF MODEL PARAMETERS.

SET JQ  PERFORMANCE MEASURES  /OP-COST  TOTAL OPERATING COSTS,
                               CO2      TOTAL CO2 EMISSIONS IN GRAMS,
                               NOX      TOTAL NOX EMISSIONS IN GRAMS,
                               PM25     TOTAL PM25 EMISSIONS IN MILLIGRAMS,
                               EM-COST  TOTAL EMISSIONS COST/;

SET JQN(JQ)  GENERAL PERFORMANCE MEASURES  /OP-COST, CO2, NOX, EM-COST/;

SET JQZ(JQ)  TIME AND ZONE SPECIFIC PERFORMANCE MEASURES  /PM25/;

SET JAC  ACTIVITY PARAMETERS  /MIN     ACTIVITY LOWER BOUND,
                               MAX     ACTIVITY UPPER BOUND,
                               PRICE   UNIT PRICE,
                               WT      OBJECTIVE FUNCTION WEIGHT/;

SET JVC  VEHICLE PARAMETERS  /SEATS      VEHICLE CAPACITY IN NUMBER OF SEATS,
                              MPG        DIESEL FUEL CONSUMPTION RATE MILES PER GALLON,
                              MCOST      MAINTENANCE COST DOLLARS PER HR,
                              CO2-HR     CO2 EMISSIONS GRAMS PER HR,
                              NOX-HR     NOX EMISSIONS GRAMS PER HR,
                              PM25-HR    PM25 EMISSIONS GRAMS PER HR,
                              PARM-CO2   CO2 EMISSIONS PER GAL OF DIESEL CONSUMED,
                              PARM-NOX   NOX PER BHP-HR,
                              PARM-PM25  PM25 PER BHP-HR,
                              THERM-EFF  THERMAL EFFICIENCY,
                              FCAP       FUEL TANK CAPACITY,
                              NV         NUMBER OF VEHICLES/;

SET JRC  ROUTE PARAMETERS  /LENGTH  ROUTE LENGTH IN MILES,
                            MPH     AVERAGE SPEED IN MILES PER HR,
                            DH      ONE-WAY DEADHEAD DISTANCE IN MILES,
                            DHT     ONE-WAY DEADHEAD TIME IN HOURS/;
```

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GAMS 25.1.3  r4e34d435fbd Released Oct 30, 2018 WEX-WEI x86 64bit/MS Windows  03/01/19 11:08:37 Page 4
TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
DECLARE AND DEFINE MODEL PARAMETERS


* OVERVIEW OF PARAMETERS
*--------------------------------------------------------------------------------------------
* PARAMETER..................  DESCRIPTION..............................................
*--------------------------------------------------------------------------------------------
* DV(JV,JVC)                   VEHICLE PARAMETER VALUES BY VEHICLE TYPE
*
* DVR(JV,JP,JR,JVC)            ROUTE-SPECIFIC VEHICLE PARAMETER VALUES BY VEHICLE TYPE AND
*                              OPERATING PRACTICES
*
* DR(JR,JZ,JRC)                ROUTE PARAMETER VALUES BY SERVICE ZONE AND ROUTE
*
* DP(JS)                       DURATION OF SCHEDULE IN PERIODS BY OPERATING SCHEDULE
*
* DSI(JTS,JS,JR,JV,JI)         NET INPUT REQ PER UNIT OF VEHICLE SCHEDULING ACT BY INPUT,
*                              VEHICLE TYPE, ROUTE, SCHEDULE & SCHEDULING PERIOD; UNITS OF
*                              INPUT PER VEHICLE ASSIGNED
*
* DSV(JTS,JS,JR,JV)            VEHICLE REQ PER UNIT OF SCHEDULING ACT BY VEHICLE TYPE,
*                              ROUTE, SCHEDULE & SCHEDULING PERIOD
*
* DSC(JTS,JS,JR,JV)            CONTRIBUTION TO VEHICLE OPER CAP PER UNIT OF VEHICLE
*                              SCHEDULING ACT BY VEHICLE TYPE, ROUTE, SCHEDULE &
*                              SCHEDULING PERIOD; HOURS PER VEHICLE ASSIGNED
*
* DI(JT,JI,JAC)                INPUT PARAMETER VALUES BY INPUT AND PLANNING PERIOD
*
* DY(JT,JR,JH,JAC)             SERVICE OR DEMAND ATTRIBUTE PARAMETER VALUES BY ATTRIBUTE,
*                              ROUTE & PLANNING PERIOD
*
* AS(JT,JT2,JS,JR,JV,JI)       NET INPUT REQUIREMENT PER UNIT OF VEHICLE SCHEDULING ACT BY
*                              INPUT, VEHICLE TYPE, ROUTE, SCHEDULE, INITIAL PERIOD &
*                              PLANNING PERIOD; UNITS OF INPUT PER VEHICLE SCHEDULED
*
* AV(JT,JT2,JS,JR,JV)          NET VEHICLE REQUIREMENT PER UNIT OF VEHICLE SCHEDULING ACT
*                              BY VEHICLE TYPE, ROUTE, SCHEDULE, INITIAL PERIOD & PLANNING
*                              PERIOD; VEHICLES PER VEHICLE SCHEDULED
*
* AC(JT,JT2,JS,JR,JV)          NET CONTRIBUTION TO VEHICLE OPERATING CAPACITY PER UNIT OF
*                              VEHICLE SCHEDULING ACT BY VEHICLE TYPE, ROUTE, SCHEDULE,
*                              INITIAL PERIOD & PLANNING PERIOD; UNITS OF INPUT PER
*                              VEHICLE SCHEDULED
*
* AO(JT,JR,JV,JP,JI)           NET INPUT REQ PER UNIT OF VEHICLE OPER ACT BY INPUT, OPER
*                              PRACTICE, VEHICLE TYPE, ROUTE & PLANNING PERIOD; INPUT
*                              UNITS PER HOUR OF OPERATION
*
* AV(JT,JT2,JS,JR,JV)          VEHICLE REQUIREMENT PER UNIT OF VEHICLE SCHEDULING ACTIVITY
*                              BY VEHICLE TYPE, ROUTE, SCHEDULE, INITIAL PERIOD & PLANNING
*                              PERIOD;  UNITS OF INPUT PER VEHICLE SCHEDULED
*
* ES(JT,JT2,JS,JR,JV,JH)       SERVICE ATTRIBUTE LEVEL PER UNIT OF VEHICLE SCHEDULING ACT
*                              BY ATTRIBUTE, VEHICLE TYPE, ROUTE, SCHEDULE, INITIAL PERIOD
*                              & PLANNING PERIOD; ATTRIBUTE UNITS PER VEHICLE SCHEDULED
*
* EO(JT,JR,JV,JP,JH)           SERVICE ATTRIBUTE LEVEL PER UNIT OF VEHICLE OPERATING ACT
*                              BY ATTRIBUTE, OPERATING PRACTICE, VEHICLE TYPE, ROUTE &
*                              PLANNING PERIOD; ATTRIBUTE UNITS PER VEHICLE SCHEDULED
*--------------------------------------------------------------------------------------------
* CONTINUED...
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
DECLARE AND DEFINE MODEL PARAMETERS
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* OVERVIEW OF PARAMETERS, CONTINUED
*------------------------------------------------------------------------------------------
* PARAMETER..................  DESCRIPTION.............................................
*------------------------------------------------------------------------------------------
* CNS(JT,JT2,JS,JR,JV,JQN)     GENERAL PERF MEASURE LEVEL PER UNIT OF VEHICLE SCHEDULING
*                              ACT BY PERF MEASURE, VEHICLE TYPE, ROUTE, SCHEDULE, INITIAL
*                              PERIOD & PLANNING PERIOD; PERF MEASURE UNITS PER VEHICLE
*                              SCHEDULED
*
* CNO(JT,JR,JV,JP,JQN)         GENERAL PERFORMANCE MEASURE LEVEL PER UNIT OF VEHICLE OPER
*                              ACT BY PERF MEASURE, OPERATING PRACTICE, VEHICLE TYPE,
*                              ROUTE, & PLANNING PERIOD; PERF MEASURE UNITS PER HR OF
*                              VEHICLE OPER
*
* CNV(JT,JI,JQN)               GENERAL PERFORMANCE MEASURE LEVEL PER UNIT OF INPUT
*                              USE/PURCH ACTIVITY BY PERF MEASURE, INPUT & PLANNING PERIOD
*
* CNY(JT,JR,JH,JQN)            GENERAL PERF MEASURE LEVEL PER UNIT OF SERVICE OR DEMAND
*                              ATTRIBUTE ACT BY PERF MEASURE, ATTRIBUTE, ROUTE & PLANNING
*                              PERIOD
*
* CZS(JT,JT2,JS,JR,JV,JZ,JQZ)  TIME & ZONE SPECIFIC PERFORMANCE MEASURE LEVEL PER UNIT OF
*                              VEHICLE SCHEDULING ACTIVITY BY PERF MEASURE, VEHICLE TYPE,
*                              ROUTE, SCHEDULE, INITIAL PERIOD & PLANNING PERIOD; PERF
*                              MEASURE UNITS PER VEHICLE SCHEDULED
*
* CZO(JT,JR,JV,JP,JZ,JQZ)      TIME & ZONE SPECIFIC PERF MEASURE LEVEL PER UNIT OF VEHICLE
*                              OPRE ACT BY PERF MEASURE, OPERATING PRACTICE, VEHICLE TYPE,
*                              ROUTE, & PLANNING PERIOD; PERF MEASURE UNITS PER HR OF
*                              VEHICLE OPER
*
* CQN(JQN,JAC)                 OBJ FUNCTION COEF & BOUNDS FOR GENERAL PERF MEASURE ACT
*
* CQZ(JT,JZ,JQZ)               OBJ FUNCTION COEF FOR TIME & ZONE SPECIFIC PERF MEASURE ACT
*
* CEM(JQ)                      EMISSIONS PRICES
*------------------------------------------------------------------------------------------
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
DECLARE AND DEFINE MODEL PARAMETERS


TABLE DV(JV,JP,JVC)  VEHICLE PARAMETER VALUES BY VEHICLE TYPE AND OPERATING PRACTICE
*------------------------------------------------------------------------------------------
               SEATS      MCOST    PARM-CO2     PARM-NOX   PARM-PM25       FCAP         NV
*------------------------------------------------------------------------------------------
B06.BASE        43     1.457491    9035.56 69.927499250    1.748200        125         22
B14.BASE        58     1.446055    9035.56  5.594199940    0.174820        125         14
B15.BASE        38     0.862164    9035.56  6.412715466    0.168756        100         24
B16.BASE        38     0.871540    9035.56 43.704687030    0.174820        125         33
B17.BASE        58     0.907264    9035.56 26.222812220    0.174820        125         15
B21.BASE        38     0.721508    9035.56 26.494640220    0.168760        100         24
B22.BASE        40     2.402240    9035.56  2.362579382    0.168760        100          1
B23.BASE        38     0.580428    9035.56 27.446543460    0.174820        125         80
B26.BASE        40     2.245278    9035.56  4.387647424    0.168760        100          1
B28.BASE        38     0.839996    9035.56  2.447462474    0.174820        125         57;
*------------------------------------------------------------------------------------------
* EMISSIONS PARAMETER VALUES ARE IN GRAMS PER GALLON OF DIESEL FUEL CONSUMED


TABLE DVR(JV,JP,JR,JVC) ROUTE-SPECIFIC VEHICLE PARAMETER VALUES BY TYPE & OPER PRACTICE
*DISPLAY DVR;

TABLE DR(JR,JZ,JRC)  ROUTE PARAMETER VALUES BY SERVICE ZONE AND ROUTE
*DISPLAY DR;

* DEADHEADING DISTANCE IS CALCULATED USING GOOGLE MAPS TO FIND THE SHORTEST DISTANCE
* BETWEEN THE DEPOT AND THE LAST STOP ON THE ROUTE.


DVR(JV,"BASE",JR,"CO2-HR")
   = DV(JV,"BASE","PARM-CO2") * DR(JR,"MAIN","MPH") / DVR(JV,"BASE",JR,"MPG");

DVR(JV,"BASE",JR,"NOX-HR")
   = DV(JV,"BASE","PARM-NOX") * DR(JR,"MAIN","MPH") / DVR(JV,"BASE",JR,"MPG");

DVR(JV,"BASE",JR,"PM25-HR")
   = DV(JV,"BASE","PARM-PM25") * DR(JR,"MAIN","MPH") / DVR(JV,"BASE",JR,"MPG");


PARAMETER DP(JS)  NUMBER OF PERIODS IN SCHEDULE;

* THE NUMBER IN THE SCHEDULE LABELS INDICATES THE NUMBER OF OPERATING PERIODS FOR THAT
* SCHEDULE.  WITH THE PERIODS PRIOR TO AND FOLLOWING THE PERIODS OF SERVICE USED FOR
* DEADHEADING TO AND FROM THE ROUTE, RESPECTIVELY, THE TOTAL NUMBER OF PERIODS IN THE
* SCHEDULE IS THE NUMBER PERIODS IN SERVICE FOR THAT SCHEDULE PLUS TWO.

DP(JS) = 0;
DP(JS) = ORD(JS) + 2;


* THE SET STRS MAPS VEHICLE TYPES, ROUTES AND SCHEDULES TO INITIAL ASSIGNMENT PERIODS.
* THE MAPPING REQUIRES THAT THE VEHICLE IS MAPPED TO THE ROUTE, THE ROUTE IS MAPPED TO THE
* SCHEDULE, & THAT THE SCHEDULE MAY BE COMPLETED BY THE LAST PLANNING PERIOD.

JTSR(JT,JS,JR,JV)$(JRV(JR,JV) AND JRS(JR,JS) AND ((ORD(JT)+DP(JS)-1) LE CARD(JT))) = YES;

PARAMETER JTSRDIM;     JTSRDIM = CARD(JTSR);

*  DISPLAY JTSRDIM;
*  DISPLAY JTSR;

  SET JTSRD(JT,JS);
  JTSRD(JT,JS)$JTSR(JT,JS,"R010","B15") = YES;

*  DISPLAY JTSRD;
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
DECLARE AND DEFINE MODEL PARAMETERS


PARAMETER DSI(JTS,JS,JR,JV,JI)  NET INPUT REQ FOR VEHICLE SCHEDULING ACTIVITY;

  DSI(JTS,JS,JR,JV,JI) = 0.0;

  DSI(JTS,JS,JR,JV,"DIESEL")$ ((ORD(JTS)=1)OR(ORD(JTS)=DP(JS)))
    = SUM(JZ,DR(JR,JZ,"DH")/DVR(JV,"BASE",JR,"MPG"));

  DSI(JTS,JS,JR,JV,"MAINT")$ ((ORD(JTS)=1)OR(ORD(JTS)=DP(JS)))
    = SUM(JZ,DR(JR,JZ,"DHT")*DV(JV,"BASE","MCOST"));


PARAMETER DSV(JTS,JS,JR,JV)  VEHICLE REQUIREMENT FOR VEHICLE SCHEDULING ACTIVITY;

  DSV(JTS,JS,JR,JV) = 0.0;

  DSV(JTS,JS,JR,JV)$((ORD(JTS)>1) AND (ORD(JTS)<DP(JS))) = 1;

  DSV(JTS,JS,JR,JV)$((ORD(JTS)=1) OR (ORD(JTS)=DP(JS))) = SUM(JZ,DR(JR,JZ,"DHT"));


PARAMETER DSC(JTS,JS,JR,JV)  CONTRIBUTION TO VEHICLE OPER CAP FOR SCHEDULING ACTIVITY;

  DSC(JTS,JS,JR,JV)$((ORD(JTS)>1) AND (ORD(JTS)<DP(JS))) = 1.0;


PARAMETER DI(JT,JI,JAC)  INPUT PARAMETER VALUES BY INPUT AND PLANNING PERIOD;

  DI(JT,JI,JAC) = 0;

  DI(JT,"DIESEL","PRICE") = 3.141;
  DI(JT,"DIESEL","MIN") = 0;
  DI(JT,"DIESEL","MAX") = INF;

  DI(JT,"MAINT","PRICE") = 1.000;
  DI(JT,"MAINT","MIN") = 0;
  DI(JT,"MAINT","MAX") = INF;


TABLE DY(JT,JR,JH,JAC)  SERVICE OR DEMAND ATTRIBUTE PARM VALUES BY ATTR ROUTE & PERIOD
*DISPLAY DY;

  DY(JT,JR,"TSEAT","PRICE") = 0;
  DY(JT,JR,"TSEAT","MAX") = INF;

  DY(JT,JR,"FREQ","PRICE") = 0;
  DY(JT,JR,"FREQ","MAX") = INF;
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
DECLARE AND DEFINE MODEL PARAMETERS


PARAMETER AS(JT,JT2,JS,JR,JV,JI)  NET INPUT REQ FOR VEHICLE SCHEDULING ACT;

  AS(JT,JT2,JS,JR,JV,JI) = 0.0;

  AS(JT,JT2,JS,JR,JV,JI) = SUM(JTS$(JTSR(JT2,JS,JR,JV)
                               AND ((ORD(JT)-ORD(JT2)+1)=ORD(JTS))),DSI(JTS,JS,JR,JV,JI));


PARAMETER AV(JT,JT2,JS,JR,JV)  VEHICLE REQ FOR VEHICLE SCHEDULING ACT;

  AV(JT,JT2,JS,JR,JV) = 0.0;

  AV(JT,JT2,JS,JR,JV) = SUM(JTS$((ORD(JT)-ORD(JT2)+1)=ORD(JTS)),DSV(JTS,JS,JR,JV));


PARAMETER AC(JT,JT2,JS,JR,JV) NET OPER CAPACITY CONTRIBUTION FOR VEHICLE SCHEDULING ACT;

  AC(JT,JT2,JS,JR,JV) = 0.0;

  AC(JT,JT2,JS,JR,JV) = SUM(JTS$(JTSR(JT2,JS,JR,JV)
                            AND ((ORD(JT)-ORD(JT2)+1)=ORD(JTS))),DSC(JTS,JS,JR,JV));


PARAMETER AO(JT,JR,JV,JP,JI)  NET INPUT REQ FOR VEHICLE OPERATING ACT;

  AO(JT,JR,JV,JP,JI) = 0.0;

  AO(JT,JR,JV,JP,"DIESEL") = SUM(JZ,DR(JR,JZ,"MPH")/DVR(JV,JP,JR,"MPG"));

  AO(JT,JR,JV,JP,"MAINT") = DV(JV,JP,"MCOST");


PARAMETER ES(JT,JT2,JS,JR,JV,JH)  SERVICE ATTRIBUTE COEF FOR VEHICLE SCHEDULING ACT;

  ES(JT,JT2,JS,JR,JV,JH) = 0.0;


PARAMETER EO(JT,JR,JV,JP,JH)  SERVICE ATTRIBUTE COEF FOR VEHICLE OPERATING ACT;

  EO(JT,JR,JV,JP,JH) = 0;

  EO(JT,JR,JV,JP,"TSEAT") = DV(JV,JP,"SEATS");

  EO(JT,JR,JV,JP,"FREQ") = 1.0;
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
DECLARE AND DEFINE MODEL PARAMETERS

PARAMETER CNS(JT,JT2,JS,JR,JV,JQN)  GENERAL PERF MEASURE COEF FOR VEHICLE SCHEDULING ACT;
  CNS(JT,JT2,JS,JR,JV,JQN) = 0;
  CNS(JT,JT2,JS,JR,JV,"CO2") = AS(JT,JT2,JS,JR,JV,"DIESEL") * DV(JV,"BASE","PARM-CO2");
  CNS(JT,JT2,JS,JR,JV,"NOX") = AS(JT,JT2,JS,JR,JV,"DIESEL") * DV(JV,"BASE","PARM-NOX");
PARAMETER CNO(JT,JR,JV,JP,JQN)  GENERAL PERFORMANCE MEASURE COEF FOR VEHICLE OPER ACT;
  CNO(JT,JR,JV,JP,JQN) = 0;
  CNO(JT,JR,JV,JP,"CO2") = AO(JT,JR,JV,JP,"DIESEL") * DV(JV,JP,"PARM-CO2");
  CNO(JT,JR,JV,JP,"NOX") = AO(JT,JR,JV,JP,"DIESEL") * DV(JV,JP,"PARM-NOX");
PARAMETER CNV(JT,JI,JQN)  GENERAL PERF MEASURE COEF FOR INPUT USE OR PURCHASE ACT;
  CNV(JT,JI,JQN) = 0;
  CNV(JT,JI,"OP-COST") = DI(JT,JI,"PRICE");
PARAMETER CNY(JT,JR,JH,JQN)  GENERAL PERF PERF MEASURE COEF FOR SERVICE ATTRIBUTE ACT;
  CNY(JT,JR,JH,JQN) = 0;
PARAMETER CZS(JT,JT2,JS,JR,JV,JZ,JQZ)  TIME & ZONE SPEC PERF MEASURE COEF FOR VEH SCH ACT;
  CZS(JT,JT2,JS,JR,JV,JZ,JQZ) = 0;
  CZS(JT,JT2,JS,JR,JV,JZ,"PM25")
      = AS(JT,JT2,JS,JR,JV,"DIESEL") * DV(JV,"BASE","PARM-PM25");
PARAMETER CZO(JT,JR,JV,JP,JZ,JQZ)  TIME & ZONE SPEC PERF MEASURE COEF FOR VEH OPER ACT;
  CZO(JT,JR,JV,JP,JZ,JQZ) = 0;
   CZO(JT,JR,JV,JP,"MAIN","PM25")
      =  AO(JT,JR,JV,JP,"DIESEL") * DV(JV,JP,"PARM-PM25");
PARAMETER CEM(JQ)  PRICES FOR CALCULATING EMISSIONS COST $ PER GRAM
          /CO2 0.0000406, NOX 0.00352551, PM25 0.01976421/;
CNS(JT,JT2,JS,JR,JV,"EM-COST") = CEM("CO2") * CNS(JT,JT2,JS,JR,JV,"CO2")
                                 + CEM("NOX") * CNS(JT,JT2,JS,JR,JV,"NOX")
                                 + CEM("PM25") * SUM(JZ,CZS(JT,JT2,JS,JR,JV,JZ,"PM25"));
CNO(JT,JR,JV,JP,"EM-COST") =  CEM("CO2") * CNO(JT,JR,JV,JP,"CO2")
                              + CEM("NOX") * CNO(JT,JR,JV,JP,"NOX")
                              + CEM("PM25") * SUM(JZ,CZO(JT,JR,JV,JP,JZ,"PM25"));
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
DECLARE AND DEFINE MODEL PARAMETERS


PARAMETER CQN(JQN,JAC)  OBJ FUNCTION COEF FOR GENERAL PERFORMANCE MEASURE ACT;

  CQN(JQN,JAC) = 0;

  CQN("OP-COST","WT") = -1.0;
  CQN("CO2","WT") = 0.0;
  CQN("NOX","WT") = 0.0;
  CQN("EM-COST","WT") = 0.0;

  CQN(JQN,"MIN") = 0;

  CQN("OP-COST","MAX") = INF;
  CQN("CO2","MAX") = INF;
  CQN("NOX","MAX") = INF;
  CQN("EM-COST","MAX") = INF;


PARAMETER CQZ(JT,JZ,JQZ)  OBJ FUNCTION COEF FOR TIME & ZONE SPECIFIC PERF MEASURE ACT;

  CQZ(JT,JZ,"PM25") = 0.0;
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
DECLARE AND DEFINE VARIABLES, EQUATIONS AND THE MODEL


VARIABLES
*----------------------------------------------------------------------------------------
* VARIABLE..........  DESCRIPTION.......................................................
*----------------------------------------------------------------------------------------
  ZOBJ                OBJECTIVE FUNCTION VALUE,
  XS(JT2,JS,JR,JV)    SCHEDULING ACTIVITY NUMBER OF VEHICLES
  XO(JT,JR,JV,JP)     VEHICLE OPERATING ACTIVITY HOURS
  V(JT,JI)            INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITY
  Y(JT,JR,JH)         SERVICE OR DEMAND ATTRIBUTE LEVEL
  QN(JQN)             GENERAL PERFORMANCE MEASURE ACTIVITY
  QZ(JT,JZ,JQZ)       TIME & ZONE SPECIFIC PERFORMANCE MEASURE;
*----------------------------------------------------------------------------------------


POSITIVE VARIABLES XO, V, Y, QN, QZ;


INTEGER VARIABLES XS;


XS.LO(JT2,JS,JR,JV) = 0;
XS.UP(JT2,JS,JR,JV) = DV(JV,"BASE","NV") + 1;

V.LO(JT,JI) = DI(JT,JI,"MIN");
V.UP(JT,JI) = DI(JT,JI,"MAX");

Y.LO(JT,JR,JH) = DY(JT,JR,JH,"MIN");
Y.UP(JT,JR,JH) = DY(JT,JR,JH,"MAX");

QN.LO(JQN) = CQN(JQN,"MIN");
QN.UP(JQN) = CQN(JQN,"MAX");


EQUATIONS
*----------------------------------------------------------------------------------------
* EQUATION.........  DESCRIPTION........................................................
*----------------------------------------------------------------------------------------
  OBJECTIVE          OBJECTIVE FUNCTION,
  INPUT(JT,JI)       INPUT USE CONSTRAINTS,
  VEHICLE(JT,JV)     VEHICLE CONSTRAINTS,
  OPCAP(JT,JR,JV)    OPERATING CAPACITY CONSTRAINTS,
  SERVICE(JT,JR,JH)  SERVICE ATTRIBUTE CONSTRAINTS,
  PERFG(JQN)         GENERAL PERFORMANCE MEASURE EQUATIONS,
  PERFTZ(JT,JZ,JQZ)  TIME & ZONE SPECIFIC PERFORMANCE MEASURE EQUATIONS;
*----------------------------------------------------------------------------------------
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
DECLARE AND DEFINE VARIABLES, EQUATIONS AND THE MODEL


OBJECTIVE..

  ZOBJ =E= SUM(JQN,CQN(JQN,"WT")*QN(JQN))
           + SUM(JT,SUM(JZ,SUM(JQZ,CQZ(JT,JZ,JQZ)*QZ(JT,JZ,JQZ))));


INPUT(JT,JI)..

  SUM(JT2,SUM(JS,SUM(JR,SUM(JV$JTSR(JT2,JS,JR,JV)
                            ,AS(JT,JT2,JS,JR,JV,JI)*XS(JT2,JS,JR,JV)))))
  + SUM(JR,SUM(JV$JRV(JR,JV),SUM(JP$JVM(JV,JP),AO(JT,JR,JV,JP,JI)*XO(JT,JR,JV,JP))))
  - V(JT,JI) =E= 0;


VEHICLE(JT,JV)..

  SUM(JT2,SUM(JS,SUM(JR$JTSR(JT2,JS,JR,JV),AV(JT,JT2,JS,JR,JV)*XS(JT2,JS,JR,JV))))
  =L= DV(JV,"BASE","NV");


OPCAP(JT,JR,JV)..

  - SUM(JT2,SUM(JS,AC(JT,JT2,JS,JR,JV)*XS(JT2,JS,JR,JV)))
     + SUM(JP$JVM(JV,JP),XO(JT,JR,JV,JP)) =E= 0;


SERVICE(JT,JR,JH)..

  SUM(JT2,SUM(JS,SUM(JV$JTSR(JT2,JS,JR,JV),ES(JT2,JT,JS,JR,JV,JH)*XS(JT2,JS,JR,JV))))
  + SUM(JV$JRV(JR,JV),SUM(JP$JVM(JV,JP),EO(JT,JR,JV,JP,JH)*XO(JT,JR,JV,JP)))
  - Y(JT,JR,JH) =E= 0;


PERFG(JQN)..

  SUM(JT,SUM(JT2,SUM(JS,SUM(JR,SUM(JV$JTSR(JT2,JS,JR,JV)
                                   ,CNS(JT,JT2,JS,JR,JV,JQN)*XS(JT2,JS,JR,JV))))))
  + SUM(JT,SUM(JR,SUM(JV$JRV(JR,JV),
                       SUM(JP$JVM(JV,JP),CNO(JT,JR,JV,JP,JQN)*XO(JT,JR,JV,JP)))))
  + SUM(JT,SUM(JI,CNV(JT,JI,JQN)*V(JT,JI)))
  + SUM(JT,SUM(JR,SUM(JH,CNY(JT,JR,JH,JQN)*Y(JT,JR,JH)))) - QN(JQN) =E= 0;


PERFTZ(JT,JZ,JQZ)..

  SUM(JT2,SUM(JS,SUM(JR,SUM(JV$JTSR(JT2,JS,JR,JV)
                            ,CZS(JT,JT2,JS,JR,JV,JZ,JQZ)*XS(JT2,JS,JR,JV)))))
  + SUM(JR,SUM(JV$JRV(JR,JV),SUM(JP$JVM(JV,JP),CZO(JT,JR,JV,JP,JZ,JQZ)*XO(JT,JR,JV,JP))))
  - QZ(JT,JZ,JQZ) =E= 0;


MODEL TRANSIT  /ALL/;


SOLVE TRANSIT USING MIP MAXIMIZING ZOBJ;
```

```
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
GENERATE AND DISPLAY RESULTS TABLES
```

```
SET JRTH RESULTS TABLE HEADERS /LOWER, LEVEL, UPPER, MARGINAL, PRICE, WT/;

OPTION ZOBJ:1;  DISPLAY ZOBJ.L;

PARAMETER RTBL01(JQN,JRTH)  GENERAL PERFORMANCE MEASURE ACTIVITY RESULTS;
  RTBL01(JQN,"LOWER") = QN.LO(JQN);
  RTBL01(JQN,"LEVEL") = QN.L(JQN);
  RTBL01(JQN,"UPPER") = QN.UP(JQN);
  RTBL01(JQN,"WT") = CQN(JQN,"WT");
  OPTION RTBL01:5:1:1;  DISPLAY$PRNT("01") RTBL01;

PARAMETER RTBL02(JT,JQZ,JZ,JRTH)  TIME & ZONE SPECIFIC PERF MEASURE ACTIVITY RESULTS;
  RTBL02(JT,JQZ,JZ,"LOWER") = QZ.LO(JT,JZ,JQZ);
  RTBL02(JT,JQZ,JZ,"LEVEL") = QZ.L(JT,JZ,JQZ);
  RTBL02(JT,JQZ,JZ,"UPPER") = QZ.UP(JT,JZ,JQZ);
  RTBL02(JT,JQZ,JZ,"WT") = CQZ(JT,JZ,JQZ);
  OPTION RTBL02:5:1:3;  DISPLAY$PRNT("02") RTBL02;

PARAMETER RTBL03(JQZ)  TIME & ZONE SPECIFIC PERF MEASURE ACTIVITIES - TOTALS;
  RTBL03(JQZ) = SUM(JT,SUM(JZ,QZ.L(JT,JZ,JQZ)));
  OPTION RTBL03:5:0:1;  DISPLAY$PRNT("03") RTBL03;

PARAMETER RTBL04(JR,JT,JV,JS)  SCHEDULING ACTIVITY RESULTS;
  RTBL04(JR,JT,JV,JS)$JTSR(JT,JS,JR,JV) = XS.L(JT,JS,JR,JV);
  OPTION RTBL04:0:2:1;  DISPLAY$PRNT("04") RTBL04;

PARAMETER RTBL05(JR,JT,JV,JP)  VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE;
  RTBL05(JR,JT,JV,JP)$(JRV(JR,JV) AND JVM(JV,JP)) = XO.L(JT,JR,JV,JP);
  OPTION RTBL05:2:1:2;  DISPLAY$PRNT("05") RTBL05;

PARAMETER RTBL06(JV,JT,JR,JP) VEHICLE OPERATING ACTIVITIES FOR EACH VEHICLE;
  RTBL06(JV,JT,JR,JP)=RTBL05(JR,JT,JV,JP);
  OPTION RTBL06:2:1:2;  DISPLAY$PRNT("06") RTBL06;

PARAMETER RTBL07(JT,JV)  VEHICLE OPERATING ACTIVITIES ON ALL ROUTES;
  RTBL07(JT,JV) = SUM(JR$JRV(JR,JV),SUM(JP$JVM(JV,JP),XO.L(JT,JR,JV,JP)));
  OPTION RTBL07:2:1:1;  DISPLAY$PRNT("07") RTBL07;

PARAMETER RTBL08(JI,JT,JRTH)  INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITIES AND BOUNDS;
  RTBL08(JI,JT,"LOWER") = V.LO(JT,JI);
  RTBL08(JI,JT,"LEVEL") = V.L(JT,JI);
  RTBL08(JI,JT,"UPPER") = V.UP(JT,JI);
  RTBL08(JI,JT,"PRICE") = CNV(JT,JI,"OP-COST");
  OPTION RTBL08:3:1:1;  DISPLAY$PRNT("08") RTBL08;

PARAMETER RTBL09(JT,JI)  INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITIES;
  RTBL09(JT,JI) = V.L(JT,JI);
  OPTION RTBL09:3:1:1;  DISPLAY$PRNT("09") RTBL09;

PARAMETER RTBL10(JR,JH,JT,JRTH)  SERVICE OR DEMAND ATTRIBUTE LEVELS;
  RTBL10(JR,JH,JT,"LOWER") = Y.LO(JT,JR,JH);
  RTBL10(JR,JH,JT,"LEVEL") = Y.L(JT,JR,JH);
  RTBL10(JR,JH,JT,"UPPER") = Y.UP(JT,JR,JH);
  OPTION RTBL10:3:1:1;  DISPLAY$PRNT("10") RTBL10;
```

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
CREATE CSV FILE OF RESULTS;


FILE TRANSITR1  /TRANSITR1.CSV/;

  TRANSITR1.PC = 5;

  TRANSITR1.ND = 4;

  PUT TRANSITR1;
  PUT "MODEL STATUS:", TRANSIT.MODELSTAT/;
  PUT "SOLVER STATUS:", TRANSIT.SOLVESTAT//;
  PUT "OBJ:", ZOBJ.L///;

  PARAMETER CTBL1(JQ,JRTH) PERF MEASURE RESULTS;
  CTBL1(JQN,"WT") = CQN(JQN,"WT");
  CTBL1(JQN,"LEVEL") = QN.L(JQN);
  CTBL1(JQZ,"LEVEL") = SUM(JT,SUM(JZ,QZ.L(JT,JZ,JQZ)));

  PUT "GENERAL PERF MEASURE ACT AND TIME & ZONE SPECIFIC ACT TOTAL: QN, QZ"//;
  PUT "PERF-MEASURE","WT","LEVEL"/;
  LOOP((JQ), PUT JQ.TL, CTBL1(JQ,"WT"), CTBL1(JQ,"LEVEL") /);

  PUT //,"TIME & ZONE SPECIFIC PERFORMANCE MEASURE ACTIVITIES: QZ"//;
  PUT "PERIOD","ZONE","PERF-MEASURE","WT","LEVEL"/;
  LOOP((JT,JZ,JQZ), PUT JT.TL, JZ.TL, JQZ.TL, CQZ(JT,JZ,JQZ), QZ.L(JT,JZ,JQZ) /);

  PUT //,"SERVICE OR DEMAND ATTRIBUTE ACTIVITIES: Y"//;
  PUT "PERIOD","ROUTE","ATTRIBUTE","LEVEL"/;
  LOOP((JT,JR,JH), PUT JT.TL, JR.TL, JH.TL, Y.L(JT,JR,JH) /);

  PUT //,"INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITIES: V"//;
  PUT "PERIOD","INPUT","LEVEL"/;
  LOOP((JT,JI), PUT JT.TL, JI.TL, V.L(JT,JI) /);

  PUT //,"VEHICLE OPERATING ACTIVITIES: XO"//;
  PUT "PERIOD","ROUTE","VEHICLE TYPE","PRACTICE","HOURS"/;
  LOOP((JT,JR,JV,JP), PUT JT.TL, JR.TL, JV.TL, JP.TL, XO.L(JT,JR,JV,JP) /);

  PUT //,"SCHEDULING ACTIVITIES: XS"//;
  PUT "INITIAL PERIOD","SCHEDULE","ROUTE","VEHICLE TYPE","LEVEL"/;
  LOOP((JT2,JS,JR,JV), PUT JT2.TL, JS.TL, JR.TL, JV.TL, XS.L(JT2,JS,JR,JV) /);

  PUTCLOSE;
```

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
Symbol Listing


SYMBOL      TYPE   REFERENCES

AC           PARAM declared      523 assigned      525       527       ref       692
AO           PARAM declared      531 assigned      533       535       537       ref       563       564
                        589      680
AS           PARAM declared      508 assigned      510       512       ref       556       557       582
                        679
AV           PARAM declared      516 assigned      518       520       ref       686
CEM          PARAM declared      592  defined      593       ref       595       596       597       599
                        600      601
CNO          PARAM declared      560 assigned      562       563       564       599       ref       599
                        600      708
CNS          PARAM declared      553 assigned      555       556       557       595       ref       595
                        596      706
CNV          PARAM declared      567 assigned      569       570       ref       709       768
CNY          PARAM declared      573 assigned      575       ref       710
CQN          PARAM declared      603 assigned      605       607       608       609       610       612
                        614      615       616       617       ref       653       654       672       734
                        794
CQZ          PARAM declared      620 assigned      622       ref       673       741       804
CTBL1        PARAM declared      793 assigned      794       795       796       ref     2*800
CZO          PARAM declared      585 assigned      587       589       ref       601       717
CZS          PARAM declared      578 assigned      580       582       ref       597       716
DI           PARAM declared      429 assigned      431       433       434       435       437       438
                        439      ref       570       647       648
DP           PARAM declared      377 assigned      384       385       ref       392       408       411
                        419      421       426
DR           PARAM declared      321  defined      321       ref       368       371       374       409
                        412      421       535
DSC          PARAM declared      424 assigned      426       ref       528
DSI          PARAM declared      404 assigned      406       409       412       ref       513
DSV          PARAM declared      415 assigned      417       419       421       ref       520
DV           PARAM declared      274  defined      274       ref       368       371       374       412
                        537      549       556       557       563       564       582       589       645
                        687
DVR          PARAM declared      292  defined      292 assigned      368       371       374
                        ref      368       371       374       409       535
DY           PARAM declared      442  defined      442 assigned      502       503       505       506
                        ref      650       651
EO           PARAM declared      545 assigned      547       549       551       ref       699
ES           PARAM declared      540 assigned      542       ref       698
INPUT        EQU   declared      662  defined      678 impl-asn      724       ref       721
JAC          SET   declared      150  defined      150       ref       429       442       603
                    control      431       605
JH           SET   declared      126  defined      126       ref       442       540       545       573
                        632      650       651       665       698       699       700     2*710       775
                        776      777       778     2*808   control       542       547       575       650
                        651      696       710       776       777       778       808
JI           SET   declared      123  defined      123       ref       404       429       508       513
                        531      567       570       631       647       648       662       679       680
                        681    2*709       764       765       766       767       768       771       772
                      2*812  control       406       431       510       512       533       569       570
                        647      648       676       709       765       766       767       768       772
                        812
JP           SET   declared      108  defined      108       ref       111       274       292       531
                        535      537       545       549       560     2*563     2*564       585     2*589
                        599      600       601       630     3*680     2*693     3*699     3*708     3*717
                        752    2*753       756       757     2*761     2*816   control       113       533
                        535      537       547       549       551       562       563       564       587
                        588      599       680       693       699       708       717       753       757
                        761      816
JQ           SET   declared      135  defined      135       ref       142       146       592       793
                      3*800  control       800
JQN          SET   declared      142  defined      142       ref       553       560       567       573
                        603      633       653       654       666     2*672       706       708       709
                      2*710      730       731       732       733       734       794       795
                    control      555       562       569       575       605       612       653       654
                        672      703       731       732       733       734       794       795
JQZ          SET   declared      146  defined      146       ref       578       585       620       634
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
Symbol Listing


SYMBOL      TYPE   REFERENCES

                        667    2*673      716      717      718      737      738      739      740
                        741      744      745      796    3*804  control      580      587      673
                        713      738      739      740      741      745      796      804
JR           SET   declared       88  defined       88      ref       92      100      116      292
                        321    2*368    2*371    2*374    2*392      404    2*409      412      415
                        421      424      442      508      512      513      516      520      523
                        527      528      531    2*535      540      545      553      556      557
                        560      563      564      573      578      582      585      589      595
                        596      597      599      600      601      629      630      632      650
                        651      664      665      678    2*679    3*680    3*686    2*692      693
                      3*698    3*699      700      705    2*706      707    2*708    2*710      715
                      2*716    3*717      748    2*749      752    2*753      756      757    2*761
                        775      776      777      778    2*808    2*816    2*820  control       94
                        102      118      367      370      373      392      406      408      411
                        417      419      421      426      502      503      505      506      510
                        512      518      520      525      527      533      535      537      542
                        547      549      551      555      556      557      562      563      564
                        575      580      581      587      588      595      599      644      645
                        650      651      678      680      686      690      696      705      707
                        710      715      717      749      753      757      761      776      777
                        778      808      816      820
JRC          SET   declared      170  defined      170      ref      321
JRS          SET   declared       92 assigned       94      ref      392
JRTBL        SET   declared       18  defined       19      ref       32
JRTH         SET   declared      726  defined      726      ref      730      737      764      775
                        793
JRV          SET   declared      100 assigned      102      ref      392      680      699      707
                        717      753      761
JS           SET   declared       79  defined       79      ref       92      116      377      385
                      2*392      399      400      404      408      411      415      419      421
                        424      426      508      512      513      516      520      523      527
                        528      540      553      556      557      578      582      595      596
                        597      629      678    2*679    3*686    2*692    3*698      705    2*706
                        715    2*716      748    2*749    2*820  control       94      118      384
                        385      392      400      406      408      411      417      419      421
                        426      510      512      518      520      525      527      542      555
                        556      557      580      581      595      644      645      678      686
                        692      698      705      715      749      820
JT           SET   declared       70  defined       70      ref       76      116    2*392      399
                        400      429      442      508      513      516      520      523      528
                        531      540      545      553      556      557      560      563      564
                        567      570      573      578      582      585      589      595      596
                        597      599      600      601      620      630      631      632      634
                        647      648      650      651      662      663      664      665      667
                      2*673      679    2*680      681      686      692      693      698    2*699
                        700      706    2*708    2*709    2*710      716    2*717      718      737
                        738      739      740      741      745      748    2*749      752      753
                        756      757      760      761      764      765      766      767      768
                        771      772      775      776      777      778      796    3*804    2*808
                      2*812    2*816  control      118      392      400      431      433      434
                        435      437      438      439      502      503      505      506      510
                        512      518      520      525      527      533      535      537      542
                        547      549      551      555      556      557      562      563      564
                        569      570      575      580      581      587      588      595      599
                        622      647      648      650      651      673      676      684      690
                        696      705      707      709      710      713      738      739      740
                        741      745      749      753      757      761      765      766      767
                        768      772      776      777      778      796      804      808      812
                        816
JT2          SET   declared       76      ref      508      512      513      516      520      523
                        527      528      540      553      556      557      578      582      595
                        596      597      629      678    2*679    3*686    2*692    3*698      705
                      2*706      715    2*716    2*820  control      510      512      518      520
                        525      527      542      555      556      557      580      581      595
                        644      645      678      686      692      698      705      715      820
JTS          SET   declared       85  defined       85      ref      404    2*408    2*411      415
                      2*419    2*421      424    2*426    2*513    2*520    2*528  control      406
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
Symbol Listing


SYMBOL      TYPE   REFERENCES

                       408      411      417      419      421      426      512      520      527
JTSR         SET   declared      116 assigned      118      392      ref      394      400      512
                       527      678      686      698      705      715      749
JTSRD        SET   declared      399 assigned      400
JTSRDIM      PARAM declared      394 assigned      394
JV           SET   declared       97  defined       97      ref      100      111      116      274
                       292    2*368    2*371    2*374      392      404      409      412      415
                       424      508      512      513      516      520      523      527      528
                       531      535      537      540      545      549      553    2*556    2*557
                       560    2*563    2*564      578    2*582      585    2*589      595      596
                       597      599      600      601      629      630      645      663      664
                       678    2*679    4*680    3*686      687    2*692    2*693    3*698    4*699
                       705    2*706      707    3*708      715    2*716    4*717      748    2*749
                       752    3*753      756      757      760    3*761    2*816    2*820
                   control      102      113      118      367      370      373      392      406
                       408      411      417      419      421      426      510      512      518
                       520      525      527      533      535      537      542      547      549
                       551      555      556      557      562      563      564      580      581
                       587      588      595      599      644      645      678      680      684
                       690      698      699      705      707      715      717      749      753
                       757      761      816      820
JVC          SET   declared      156  defined      156      ref      274      292
JVM          SET   declared      111 assigned      113      ref      680      693      699      708
                       717      753      761
JZ           SET   declared      130  defined      130      ref      321      409      412      421
                       535      578      585      597      601      620      634      667    2*673
                       716      717      718      737      738      739      740      741      745
                       796    3*804  control      409      412      421      535      580      581
                       587      597      601      622      673      713      738      739      740
                       741      745      796      804
OBJECTIVE    EQU   declared      661  defined      672 impl-asn      724      ref      721
OPCAP        EQU   declared      664  defined      692 impl-asn      724      ref      721
PERFG        EQU   declared      666  defined      705 impl-asn      724      ref      721
PERFTZ       EQU   declared      667  defined      715 impl-asn      724      ref      721
PRNT         PARAM declared       32  defined       32      ref      735      742      746      750
                       754      758      762      769      773      779
QN           VAR   declared      633 impl-asn      724 assigned      653      654      ref      638
                       672      710      731      732      733      795
QZ           VAR   declared      634 impl-asn      724      ref      638      673      718      738
                       739      740      745      796      804
RTBL01       PARAM declared      730 assigned      731      732      733      734      ref    2*735
RTBL02       PARAM declared      737 assigned      738      739      740      741      ref    2*742
RTBL03       PARAM declared      744 assigned      745      ref    2*746
RTBL04       PARAM declared      748 assigned      749      ref    2*750
RTBL05       PARAM declared      752 assigned      753      ref    2*754      757
RTBL06       PARAM declared      756 assigned      757      ref    2*758
RTBL07       PARAM declared      760 assigned      761      ref    2*762
RTBL08       PARAM declared      764 assigned      765      766      767      768      ref    2*769
RTBL09       PARAM declared      771 assigned      772      ref    2*773
RTBL10       PARAM declared      775 assigned      776      777      778      ref    2*779
SERVICE      EQU   declared      665  defined      698 impl-asn      724      ref      721
TRANSIT      MODEL declared      721  defined      721 impl-asn      724      ref      724      789
                       790
TRANSITR1    FILE  declared      782  defined      782 assigned      784      786      ref      788
V            VAR   declared      631 impl-asn      724 assigned      647      648      ref      638
                       681      709      765      766      767      772      812
VEHICLE      EQU   declared      663  defined      686 impl-asn      724      ref      721
XO           VAR   declared      630 impl-asn      724      ref      638      680      693      699
                       708      717      753      761      816
XS           VAR   declared      629 impl-asn      724 assigned      644      645      ref      641
                       679      686      692      698      706      716      749      820
Y            VAR   declared      632 impl-asn      724 assigned      650      651      ref      638
                       700      710      776      777      778      808
ZOBJ         VAR   declared      628 impl-asn      724      ref      672      724    2*728      791
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
Symbol Listing


SETS

JAC           ACTIVITY PARAMETERS
JH            SERVICE OR DEMAND ATTRIBUTES
JI            INPUTS AND RESOURCES
JP            OPERATING PRACTICES
JQ            PERFORMANCE MEASURES
JQN           GENERAL PERFORMANCE MEASURES
JQZ           TIME AND ZONE SPECIFIC PERFORMANCE MEASURES
JR            ROUTES
JRC           ROUTE PARAMETERS
JRS           SCHEDULES MAPPED TO ROUTES
JRTBL         RESULTS TABLES
JRTH          RESULTS TABLE HEADERS
JRV           VEHICLE TYPES MAPPED TO ROUTES
JS            OPERATING SCHEDULES
JT            PLANNING PERIODS
JT2           Aliased with JT
JTS           PERIODS OF OPERATION
JTSR          VEHICLE TYPES ROUTES & OP SCHEDULES MAPPED TO INITIAL PERIODS
JTSRD
JV            VEHICLE TYPES
JVC           VEHICLE PARAMETERS
JVM           OPERATING PRACTICES MAPPED TO VEHICLE TYPES
JZ            GEOGRAPHIC SERVICE ZONES

PARAMETERS

AC            NET OPER CAPACITY CONTRIBUTION FOR VEHICLE SCHEDULING ACT
AO            NET INPUT REQ FOR VEHICLE OPERATING ACT
AS            NET INPUT REQ FOR VEHICLE SCHEDULING ACT
AV            VEHICLE REQ FOR VEHICLE SCHEDULING ACT
CEM           PRICES FOR CALCULATING EMISSIONS COST $ PER GRAM
CNO           GENERAL PERFORMANCE MEASURE COEF FOR VEHICLE OPER ACT
CNS           GENERAL PERF MEASURE COEF FOR VEHICLE SCHEDULING ACT
CNV           GENERAL PERF MEASURE COEF FOR INPUT USE OR PURCHASE ACT
CNY           GENERAL PERF PERF MEASURE COEF FOR SERVICE ATTRIBUTE ACT
CQN           OBJ FUNCTION COEF FOR GENERAL PERFORMANCE MEASURE ACT
CQZ           OBJ FUNCTION COEF FOR TIME & ZONE SPECIFIC PERF MEASURE ACT
CTBL1         PERF MEASURE RESULTS
CZO           TIME & ZONE SPEC PERF MEASURE COEF FOR VEH OPER ACT
CZS           TIME & ZONE SPEC PERF MEASURE COEF FOR VEH SCH ACT
DI            INPUT PARAMETER VALUES BY INPUT AND PLANNING PERIOD
DP            NUMBER OF PERIODS IN SCHEDULE
DR            ROUTE PARAMETER VALUES BY SERVICE ZONE AND ROUTE
DSC           CONTRIBUTION TO VEHICLE OPER CAP FOR SCHEDULING ACTIVITY
DSI           NET INPUT REQ FOR VEHICLE SCHEDULING ACTIVITY
DSV           VEHICLE REQUIREMENT FOR VEHICLE SCHEDULING ACTIVITY
DV            VEHICLE PARAMETER VALUES BY VEHICLE TYPE AND OPERATING PRACTICE
DVR           ROUTE-SPECIFIC VEHICLE PARAMETER VALUES BY TYPE & OPER PRACTICE
DY            SERVICE OR DEMAND ATTRIBUTE PARM VALUES BY ATTR ROUTE & PERIOD
EO            SERVICE ATTRIBUTE COEF FOR VEHICLE OPERATING ACT
ES            SERVICE ATTRIBUTE COEF FOR VEHICLE SCHEDULING ACT
JTSRDIM
PRNT          PRINT CONTROL
RTBL01        GENERAL PERFORMANCE MEASURE ACTIVITY RESULTS
RTBL02        TIME & ZONE SPECIFIC PERF MEASURE ACTIVITY RESULTS
RTBL03        TIME & ZONE SPECIFIC PERF MEASURE ACTIVITIES - TOTALS
RTBL04        SCHEDULING ACTIVITY RESULTS
RTBL05        VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE
RTBL06        VEHICLE OPERATING ACTIVITIES FOR EACH VEHICLE
RTBL07        VEHICLE OPERATING ACTIVITIES ON ALL ROUTES
RTBL08        INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITIES AND BOUNDS
RTBL09        INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITIES
RTBL10        SERVICE OR DEMAND ATTRIBUTE LEVELS
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GAMS 25.1.3  r4e34d435fbd Released Oct 30, 2018 WEX-WEI x86 64bit/MS Windows 03/01/19 11:08:37 Page 19
TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
Symbol Listing


VARIABLES

QN            GENERAL PERFORMANCE MEASURE ACTIVITY
QZ            TIME & ZONE SPECIFIC PERFORMANCE MEASURE
V             INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITY
XO            VEHICLE OPERATING ACTIVITY HOURS
XS            SCHEDULING ACTIVITY NUMBER OF VEHICLES
Y             SERVICE OR DEMAND ATTRIBUTE LEVEL
ZOBJ          OBJECTIVE FUNCTION VALUE

EQUATIONS

INPUT         INPUT USE CONSTRAINTS
OBJECTIVE     OBJECTIVE FUNCTION
OPCAP         OPERATING CAPACITY CONSTRAINTS
PERFG         GENERAL PERFORMANCE MEASURE EQUATIONS
PERFTZ        TIME & ZONE SPECIFIC PERFORMANCE MEASURE EQUATIONS
SERVICE       SERVICE ATTRIBUTE CONSTRAINTS
VEHICLE       VEHICLE CONSTRAINTS

MODELS

TRANSIT

FILES

TRANSITR1
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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
Include File Summary


   SEQ   GLOBAL TYPE      PARENT   LOCAL  FILENAME

     1        1 INPUT          0       0  C:\1 Research\Transit\TRANSIT-OP-V03 Doc Version Jan 2019.gm
                                          s
     2      294 INCLUDE        1     294  .C:\1 Research\Transit\TRANSIT-OP-DVR.INC
     3      323 INCLUDE        1     301  .C:\1 Research\Transit\TRANSIT-OP-DR.INC
     4      444 INCLUDE        1     387  .C:\1 Research\Transit\TRANSIT-OP-DY.INC


COMPILATION TIME     =        0.016 SECONDS      3 MB  25.1.3 r4e34d435fbd WEX-WEI
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GAMS 25.1.3  r4e34d435fbd Released Oct 30, 2018 WEX-WEI x86 64bit/MS Windows 03/01/19 11:08:37 Page 21
TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
Model Statistics    SOLVE TRANSIT Using MIP From line 724


MODEL STATISTICS

BLOCKS OF EQUATIONS           7     SINGLE EQUATIONS        6,363
BLOCKS OF VARIABLES           7     SINGLE VARIABLES       54,443  681 projected
NON ZERO ELEMENTS     1,286,368     DISCRETE VARIABLES     48,300


GENERATION TIME      =        0.860 SECONDS    182 MB  25.1.3 r4e34d435fbd WEX-WEI


EXECUTION TIME       =        5.313 SECONDS    182 MB  25.1.3 r4e34d435fbd WEX-WEI
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GAMS 25.1.3  r4e34d435fbd Released Oct 30, 2018 WEX-WEI x86 64bit/MS Windows 03/01/19 11:08:37 Page 22
TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
Solution Report     SOLVE TRANSIT Using MIP From line 724


               S O L V E      S U M M A R Y

     MODEL   TRANSIT             OBJECTIVE  ZOBJ
     TYPE    MIP                 DIRECTION  MAXIMIZE
     SOLVER  OSICPLEX            FROM LINE  724

**** SOLVER STATUS     1 Normal Completion
**** MODEL STATUS      8 Integer Solution
**** OBJECTIVE VALUE           -14215.6172

 RESOURCE USAGE, LIMIT         19.854      1200.000
 ITERATION COUNT, LIMIT     17439    2000000000

OSI CPLEX        25.1.3 r4e34d435fbd Released Oct 30, 2018 WEI x86 64bit/MS Wi

OsiCplex (Osi library 0.107, CPLEX library 120800.00)
CPXPARAM_Advance                                0
CPXPARAM_TimeLimit                              1200
CPXPARAM_Threads                                1
CPXPARAM_MIP_Tolerances_AbsMIPGap               0
Tried aggregator 2 times.
MIP Presolve eliminated 1841 rows and 8306 columns.
MIP Presolve modified 1922 coefficients.
Aggregator did 200 substitutions.
Reduced MIP has 4317 rows, 45936 columns, and 691090 nonzeros.
Reduced MIP has 7020 binaries, 35496 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.39 sec. (447.54 ticks)
Found incumbent of value -41295.495209 after 1.44 sec. (1718.36 ticks)
Tried aggregator 2 times.
MIP Presolve eliminated 229 rows and 170 columns.
MIP Presolve modified 3519 coefficients.
Aggregator did 2510 substitutions.
Reduced MIP has 1578 rows, 43256 columns, and 680138 nonzeros.
Reduced MIP has 9654 binaries, 33602 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.55 sec. (507.90 ticks)
Probing fixed 0 vars, tightened 180 bounds.
Probing time = 0.70 sec. (1086.50 ticks)
Clique table members: 1470.
MIP emphasis: balance optimality and feasibility.
MIP search method: dynamic search.
Parallel mode: none, using 1 thread.
Root relaxation solution time = 0.42 sec. (822.58 ticks)

        Nodes                                         Cuts/
   Node  Left     Objective  IInf  Best Integer    Best Bound    ItCnt     Gap
*     0+    0                       -41295.4952        0.0000           100.00%
      0     0   -14197.3890   116   -41295.4952   -14197.3890     2362   65.62%
      0     0   -14208.5942   121   -41295.4952      Cuts: 28     2458   65.59%
      0     0   -14209.5986   134   -41295.4952      Cuts: 13     2504   65.59%
      0     0   -14209.7030    83   -41295.4952       Cuts: 7     2512   65.59%
*     0+    0                       -14227.2893   -14209.7030             0.12%
*     0+    0                       -14225.1974   -14209.7030             0.11%
*     0+    0                       -14224.5523   -14209.7030             0.10%
*     0+    0                       -14222.2673   -14209.7030             0.09%

Repeating presolve.
Tried aggregator 2 times.
MIP Presolve eliminated 314 rows and 28829 columns.
MIP Presolve modified 313 coefficients.
Aggregator did 186 substitutions.
Reduced MIP has 1078 rows, 14241 columns, and 194022 nonzeros.
Reduced MIP has 6313 binaries, 7928 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.31 sec. (247.89 ticks)
Tried aggregator 1 time.
Reduced MIP has 1078 rows, 14241 columns, and 194022 nonzeros.
Reduced MIP has 6313 binaries, 7928 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.08 sec. (70.99 ticks)
Represolve time = 0.53 sec. (522.70 ticks)
Probing time = 0.00 sec. (19.09 ticks)
```

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
Solution Report     SOLVE TRANSIT Using MIP From line 724


Cover probing fixed 0 vars, tightened 42 bounds.
Clique table members: 1159.
MIP emphasis: balance optimality and feasibility.
MIP search method: dynamic search.
Parallel mode: none, using 1 thread.
Root relaxation solution time = 0.14 sec. (217.39 ticks)

        Nodes                                         Cuts/
   Node  Left     Objective  IInf  Best Integer    Best Bound    ItCnt     Gap
*     0+    0                      -14222.2673   -14209.7030             0.09%
      0     0   -14209.7030    74   -14222.2673   -14209.7030     4111    0.09%
      0     0   -14210.4710    69   -14222.2673   ZeroHalf: 1     4118    0.08%
      0     0   -14210.4714    85   -14222.2673       Cuts: 4     4123    0.08%
      0     0   -14210.4714    85   -14222.2673   ZeroHalf: 2     4125    0.08%
*     0+    0                      -14220.7490   -14210.4714             0.07%
      0     2   -14210.4714    85   -14220.7490   -14210.4714     4125    0.07%
Elapsed time = 8.72 sec. (11780.01 ticks, tree = 0.01 MB
     20    22   -14210.9349    53   -14220.7490   -14210.4714     4310    0.07%
     40    42   -14211.0994    51   -14220.7490   -14210.4714     4593    0.07%
     60    62   -14212.1733    50   -14220.7490   -14210.4714     4859    0.07%
     81    83   -14217.4326    73   -14220.7490   -14210.4714     5607    0.07%
    110   108   -14211.1742    67   -14220.7490   -14210.4714     6003    0.07%
    138   136   -14215.5349    62   -14220.7490   -14210.4714     6484    0.07%
    160   156   -14219.6492    59   -14220.7490   -14210.4714     7058    0.07%
*   200+  141                      -14217.5021   -14210.4714             0.05%
    200   143   -14211.8690    86   -14217.5021   -14210.4714     7456    0.05%
    221   164   -14214.9666    56   -14217.5021   -14210.4714     7813    0.05%
    382   311   -14215.0223    39   -14217.5021   -14210.4900     9961    0.05%
Elapsed time = 11.19 sec. (15158.74 ticks, tree = 7.09 MB
*   494+  396                      -14217.2213   -14210.5227             0.05%
    539   443   -14216.2419    92   -14217.2213   -14210.5509    11965    0.05%
*   604+  329                      -14216.8337   -14212.1865             0.03%
*   604+  218                      -14215.6172   -14213.7880             0.01%
    604   219   -14213.7880   109   -14215.6172   -14213.7888    15567    0.01%
    654   193   -14214.7483    50   -14215.6172   -14214.0646    16266    0.01%

Cover cuts applied:  4
Mixed integer rounding cuts applied:  31
Zero-half cuts applied:  10
Lift and project cuts applied:  5
Gomory fractional cuts applied:  10

Root node processing (before b&c):
  Real time             =    8.72 sec. (11772.87 ticks)
Sequential b&c:
  Real time             =   11.14 sec. (14243.56 ticks)
                          ------------
Total (root+branch&cut) =   19.86 sec. (26016.43 ticks)

Solved to optimality within gap tolerances.
MIP solution:   -1.421562e+04   (746 nodes, 19.854 seconds)
Best possible:  -1.421422e+04
Absolute gap:    1.400853e+00   (absolute tolerance optca: 0)
Relative gap:    9.854327e-05   (relative tolerance optcr: 0.0001)


**** REPORT SUMMARY :        0     NONOPT
                             0 INFEASIBLE
                             0  UNBOUNDED
                            45  PROJECTED
```

----   728 VARIABLE ZOBJ.L   =   -14215.6 OBJECTIVE FUNCTION VALUE

----   735 PARAMETER RTBL01 GENERAL PERFORMANCE MEASURE ACTIVITY RESULTS

	WT	LEVEL	UPPER
OP-COST	-1.00000	14215.61719	+INF
CO2		3.790024E+7	+INF
NOX		84759.84367	+INF
EM-COST		1852.06242	+INF

----   742 PARAMETER RTBL02 TIME & ZONE SPECIFIC PERF MEASURE ACTIVITY RESULTS

	PM25 MAIN LEVEL	PM25 MAIN UPPER
T04	6.16434	+INF
T05	29.26719	+INF
T06	50.31032	+INF
T07	87.46284	+INF
T08	58.12120	+INF
T09	30.65620	+INF
T10	25.75135	+INF
T11	25.59122	+INF
T12	26.65624	+INF
T13	33.81795	+INF
T14	33.92646	+INF
T15	55.20435	+INF
T16	76.48652	+INF
T17	57.39457	+INF
T18	46.12299	+INF
T19	24.78821	+INF
T20	17.86768	+INF
T21	14.27586	+INF
T22	12.60281	+INF
T23	10.75444	+INF
T24	7.79259	+INF
T25	2.18027	+INF

----   746 PARAMETER RTBL03 TIME & ZONE SPECIFIC PERF MEASURE ACTIVITIES - TOTALS

PM25 733.19561

----   750 PARAMETER RTBL04 SCHEDULING ACTIVITY RESULTS

INDEX 1 = R003

	OS01	OS02	OS03	OS07	OS10	OS11	OS14
T04.B15							1
T05.B15					1		
T06.B28	2						
T10.B15						1	
T11.B15					1		
T14.B28			1				
T15.B28		2					
T16.B15				1			

+	OS15	OS20
T04.B15	1	1

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

750 PARAMETER RTBL04 SCHEDULING ACTIVITY RESULTS

INDEX 1 = R004

	OS02	OS05	OS08	OS09	OS12	OS13
T04.B15		1				2
T06.B15					1	
T08.B15				1		
T13.B15			2			
T14.B21				1		
T15.B21				1		
T16.B15	1					

INDEX 1 = R005

	OS01	OS11	OS14	OS18	OS19
T04.B21				1	2
T05.B21		1	2		
T06.B21		1		1	
T09.B22	1				

INDEX 1 = R007

	OS01	OS18	OS20
T04.B15		1	
T04.B21			1
T15.B28	1		

INDEX 1 = R009

	OS03	OS04	OS10	OS11	OS17
T04.B15	1	1			
T06.B15			1		1
T13.B15				1	

INDEX 1 = R010

	OS03	OS04	OS05	OS06	OS11	OS12	OS13
T04.B15					1		
T04.B23			1			1	1
T05.B23						1	
T06.B23						1	
T09.B21			1				
T14.B23	1						
T15.B23		1					
T17.B21		1		1			
T18.B21				1			

INDEX 1 = R014

	OS01	OS04	OS10	OS13	OS14	OS20
T04.B21		1		1		1
T05.B21					1	
T09.B21	1					
T13.B21			1			

INDEX 1 = R016

	OS01	OS02	OS03	OS04	OS07	OS11	OS16
T04.B15						1	1
T05.B15					1		
T12.B06	1						

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

750 PARAMETER RTBL04 SCHEDULING ACTIVITY RESULTS

INDEX 1 = R016

	OS01	OS02	OS03	OS04	OS07	OS11	OS16
T13.B28				1			
T15.B28		1					
T17.B21			1		1		
T20.B22				1			

INDEX 1 = R018

	OS13	OS14	OS15	OS16	OS17	OS18
T04.B28	1		1	1		
T05.B28		1			1	
T06.B28						3

INDEX 1 = R019

	OS12	OS14	OS18	OS19
T04.B21			1	1
T05.B21				1
T05.B28	1	1		
T06.B28		1		

INDEX 1 = R022

	OS02	OS05	OS09	OS12	OS14	OS20
T04.B21		1			1	1
T05.B21				1		
T06.B21	1					
T14.B21			1			

INDEX 1 = R025

	OS01	OS02	OS04	OS10
T04.B21				1
T05.B15			1	
T06.B16	1			
T14.B16		1	1	
T17.B15	1			

INDEX 1 = R050

	OS01	OS02	OS05	OS06
T05.B16		1		
T06.B16		1		
T07.B14		1		
T09.B16	1			
T11.B16				1
T13.B16			1	

INDEX 1 = R061

	OS03	OS04	OS08	OS11	OS13
T04.B15	1				1
T06.B15				1	
T14.B15		1			
T15.B15			1		

750 PARAMETER RTBL04 SCHEDULING ACTIVITY RESULTS

INDEX 1 = R094

	OS02	OS03	OS04	OS05	OS11	OS20
T04.B23		2				
T04.B26						1
T05.B23	1	2				
T06.B23					1	
T13.B23				1		
T14.B23			1			
T15.B23		1				

INDEX 1 = R250

	OS01	OS02	OS03	OS04	OS07
T04.B17			1		
T04.B22				1	
T05.B17		2			
T06.B17	3	6			
T12.B22					1
T14.B17		5			
T15.B17	1	3	2		

INDEX 1 = R649

	OS02	OS03
T05.B16	1	1
T14.B16		1
T15.B16		1

INDEX 1 = R652

	OS02	OS04
T06.B15	1	
T14.B15		1

INDEX 1 = R667

	OS02	OS03	OS04
T04.B23	1		
T05.B23	2		1
T14.B23	1	1	
T15.B23	1	1	

INDEX 1 = R672

	OS02	OS03
T05.B23	1	1
T14.B23	1	
T15.B23		1

INDEX 1 = R674

	OS01	OS02
T05.B15	1	1
T15.B15	1	1

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

750 PARAMETER RTBL04 SCHEDULING ACTIVITY RESULTS

INDEX 1 = R675

	OS01	OS04	OS12	OS13
T04.B21				1
T05.B21			1	
T17.B06	1			
T18.B21		1		

INDEX 1 = R766

	OS01	OS02	OS03	OS10
T04.B16			3	
T05.B16		1		
T06.B16	3	4	1	
T10.B16				1
T14.B16		1		

----   754 PARAMETER RTBL05 VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE

INDEX 1 = R003

	B15.BASE	B28.BASE
T05	3.00	
T06	4.00	
T07	4.00	2.00
T08	4.00	
T09	4.00	
T10	4.00	
T11	5.00	
T12	6.00	
T13	6.00	
T14	6.00	
T15	6.00	1.00
T16	5.00	3.00
T17	6.00	3.00
T18	6.00	
T19	5.00	
T20	4.00	
T21	4.00	
T22	2.00	
T23	2.00	
T24	1.00	

INDEX 1 = R004

	B15.BASE	B21.BASE
T05	3.00	
T06	3.00	
T07	4.00	
T08	4.00	
T09	5.00	
T10	4.00	
T11	4.00	
T12	4.00	
T13	4.00	
T14	6.00	
T15	6.00	1.00
T16	6.00	2.00
T17	7.00	2.00
T18	4.00	2.00
T19	2.00	2.00
T20	2.00	2.00

754 PARAMETER RTBL05 VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE

INDEX 1 = R004

	B15.BASE	B21.BASE
T21	2.00	2.00
T22		2.00
T23		2.00
T24		1.00

INDEX 1 = R005

	B21.BASE	B22.BASE
T05	3.00	
T06	6.00	
T07	8.00	
T08	8.00	
T09	8.00	
T10	8.00	1.00
T11	8.00	
T12	8.00	
T13	8.00	
T14	8.00	
T15	8.00	
T16	8.00	
T17	7.00	
T18	6.00	
T19	6.00	
T20	4.00	
T21	4.00	
T22	4.00	
T23	3.00	
T24	1.00	

INDEX 1 = R007

	B15.BASE	B21.BASE	B28.BASE
T05	1.00	1.00	
T06	1.00	1.00	
T07	1.00	1.00	
T08	1.00	1.00	
T09	1.00	1.00	
T10	1.00	1.00	
T11	1.00	1.00	
T12	1.00	1.00	
T13	1.00	1.00	
T14	1.00	1.00	
T15	1.00	1.00	
T16	1.00	1.00	1.00
T17	1.00	1.00	
T18	1.00	1.00	
T19	1.00	1.00	
T20	1.00	1.00	
T21	1.00	1.00	
T22	1.00	1.00	
T23		1.00	
T24		1.00	

INDEX 1 = R009

	B15.BASE
T05	2.00
T06	2.00
T07	4.00
T08	3.00

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

754 PARAMETER RTBL05 VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE

INDEX 1 = R009

	B15.BASE
T09	2.00
T10	2.00
T11	2.00
T12	2.00
T13	2.00
T14	3.00
T15	3.00
T16	3.00
T17	2.00
T18	2.00
T19	2.00
T20	2.00
T21	2.00
T22	2.00
T23	2.00
T24	1.00

INDEX 1 = R010

	B15.BASE	B21.BASE	B23.BASE
T05	1.00		3.00
T06	1.00		4.00
T07	1.00		5.00
T08	1.00		5.00
T09	1.00		5.00
T10	1.00	1.00	4.00
T11	1.00	1.00	4.00
T12	1.00	1.00	4.00
T13	1.00	1.00	4.00
T14	1.00	1.00	4.00
T15	1.00		5.00
T16			6.00
T17			5.00
T18		2.00	2.00
T19		3.00	1.00
T20		3.00	
T21		3.00	
T22		2.00	
T23		2.00	
T24		1.00	

INDEX 1 = R014

	B21.BASE
T05	3.00
T06	4.00
T07	4.00
T08	4.00
T09	3.00
T10	4.00
T11	3.00
T12	3.00
T13	3.00
T14	4.00
T15	4.00
T16	4.00
T17	4.00
T18	3.00
T19	3.00
T20	2.00
T21	2.00

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

754 PARAMETER RTBL05 VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE

INDEX 1 = R014

	B21.BASE
T22	2.00
T23	2.00
T24	1.00

INDEX 1 = R016

	B06.BASE	B15.BASE	B21.BASE	B22.BASE	B28.BASE
T05		2.00			
T06		3.00			
T07		3.00			
T08		3.00			
T09		3.00			
T10		3.00			
T11		3.00			
T12		3.00			
T13	1.00	2.00			
T14		2.00			1.00
T15		2.00			1.00
T16		1.00			2.00
T17		1.00			2.00
T18		1.00	2.00		
T19		1.00	2.00		
T20		1.00	2.00		
T21			1.00	1.00	
T22			1.00	1.00	
T23			1.00	1.00	
T24			1.00	1.00	

INDEX 1 = R018

	B28.BASE
T05	3.00
T06	5.00
T07	8.00
T08	8.00
T09	8.00
T10	8.00
T11	8.00
T12	8.00
T13	8.00
T14	8.00
T15	8.00
T16	8.00
T17	8.00
T18	7.00
T19	7.00
T20	5.00
T21	4.00
T22	4.00
T23	3.00
T24	3.00

INDEX 1 = R019

	B21.BASE	B28.BASE
T05	2.00	
T06	3.00	2.00
T07	3.00	3.00
T08	3.00	3.00
T09	3.00	3.00

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754 PARAMETER RTBL05 VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE

INDEX 1 = R019

	B21.BASE	B28.BASE
T10	3.00	3.00
T11	3.00	3.00
T12	3.00	3.00
T13	3.00	3.00
T14	3.00	3.00
T15	3.00	3.00
T16	3.00	3.00
T17	3.00	3.00
T18	3.00	2.00
T19	3.00	2.00
T20	3.00	1.00
T21	3.00	
T22	3.00	
T23	2.00	
T24	1.00	

INDEX 1 = R022

	B21.BASE
T05	3.00
T06	4.00
T07	5.00
T08	5.00
T09	4.00
T10	3.00
T11	3.00
T12	3.00
T13	3.00
T14	3.00
T15	4.00
T16	4.00
T17	4.00
T18	3.00
T19	2.00
T20	2.00
T21	2.00
T22	2.00
T23	2.00
T24	1.00

INDEX 1 = R025

	B15.BASE	B16.BASE	B21.BASE
T05			1.00
T06	1.00		1.00
T07	1.00	1.00	1.00
T08	1.00		1.00
T09	1.00		1.00
T10			1.00
T11			1.00
T12			1.00
T13			1.00
T14			1.00
T15		2.00	
T16		2.00	
T17		1.00	
T18	1.00	1.00	

754 PARAMETER RTBL05 VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE

INDEX 1 = R050

	B14.BASE	B16.BASE
T06		1.00
T07		2.00
T08	1.00	1.00
T09	1.00	
T10		1.00
T12		1.00
T13		1.00
T14		2.00
T15		2.00
T16		2.00
T17		2.00
T18		1.00

INDEX 1 = R061

	B15.BASE
T05	2.00
T06	2.00
T07	3.00
T08	2.00
T09	2.00
T10	2.00
T11	2.00
T12	2.00
T13	2.00
T14	2.00
T15	3.00
T16	4.00
T17	4.00
T18	2.00
T19	1.00
T20	1.00
T21	1.00
T22	1.00
T23	1.00

INDEX 1 = R094

	B23.BASE	B26.BASE
T05	2.00	1.00
T06	5.00	1.00
T07	6.00	1.00
T08	3.00	1.00
T09	1.00	1.00
T10	1.00	1.00
T11	1.00	1.00
T12	1.00	1.00
T13	1.00	1.00
T14	2.00	1.00
T15	3.00	1.00
T16	4.00	1.00
T17	4.00	1.00
T18	3.00	1.00
T19		1.00
T20		1.00
T21		1.00
T22		1.00
T23		1.00
T24		1.00

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        754 PARAMETER RTBL05  VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE

INDEX 1 = R250

       B17.BASE    B22.BASE

T05        1.00        1.00
T06        3.00        1.00
T07       12.00        1.00
T08        6.00        1.00
T13                    1.00
T14                    1.00
T15        5.00        1.00
T16       11.00        1.00
T17        5.00        1.00
T18        2.00        1.00
T19                    1.00

INDEX 1 = R649

       B16.BASE

T06        2.00
T07        2.00
T08        1.00
T15        1.00
T16        2.00
T17        2.00
T18        1.00

INDEX 1 = R652

       B15.BASE

T07        1.00
T08        1.00
T15        1.00
T16        1.00
T17        1.00
T18        1.00

INDEX 1 = R667

       B23.BASE

T05        1.00
T06        4.00
T07        3.00
T08        1.00
T09        1.00
T15        2.00
T16        4.00
T17        3.00
T18        1.00

INDEX 1 = R672

       B23.BASE

T06        2.00
T07        2.00
T08        1.00
T15        1.00
T16        2.00
T17        1.00
T18        1.00
```

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754 PARAMETER RTBL05 VEHICLE OPERATING ACTIVITIES FOR EACH ROUTE

INDEX 1 = R674

	B15.BASE
T06	2.00
T07	1.00
T16	2.00
T17	1.00

INDEX 1 = R675

	B06.BASE	B21.BASE
T05		1.00
T06		2.00
T07		2.00
T08		2.00
T09		2.00
T10		2.00
T11		2.00
T12		2.00
T13		2.00
T14		2.00
T15		2.00
T16		2.00
T17		2.00
T18	1.00	
T19		1.00
T20		1.00
T21		1.00
T22		1.00

INDEX 1 = R766

	B16.BASE
T05	3.00
T06	4.00
T07	12.00
T08	5.00
T09	1.00
T11	1.00
T12	1.00
T13	1.00
T14	1.00
T15	2.00
T16	2.00
T17	1.00
T18	1.00
T19	1.00
T20	1.00

----   758 PARAMETER RTBL06 VEHICLE OPERATING ACTIVITIES FOR EACH VEHICLE

INDEX 1 = B06

	R016.BASE	R675.BASE
T13	1.00	
T18		1.00

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758 PARAMETER RTBL06 VEHICLE OPERATING ACTIVITIES FOR EACH VEHICLE

INDEX 1 = B14

	R050.BASE
T08	1.00
T09	1.00

INDEX 1 = B15

	R003.BASE	R004.BASE	R007.BASE	R009.BASE	R010.BASE	R016.BASE	R025.BASE	R061.BASE
T05	3.00	3.00	1.00	2.00	1.00	2.00		2.00
T06	4.00	3.00	1.00	2.00	1.00	3.00	1.00	2.00
T07	4.00	4.00	1.00	4.00	1.00	3.00	1.00	3.00
T08	4.00	4.00	1.00	3.00	1.00	3.00	1.00	2.00
T09	4.00	5.00	1.00	2.00	1.00	3.00	1.00	2.00
T10	4.00	4.00	1.00	2.00	1.00	3.00		2.00
T11	5.00	4.00	1.00	2.00	1.00	3.00		2.00
T12	6.00	4.00	1.00	2.00	1.00	3.00		2.00
T13	6.00	4.00	1.00	2.00	1.00	2.00		2.00
T14	6.00	6.00	1.00	3.00	1.00	2.00		2.00
T15	6.00	6.00	1.00	3.00	1.00	2.00		3.00
T16	5.00	6.00	1.00	3.00		1.00		4.00
T17	6.00	7.00	1.00	2.00		1.00		4.00
T18	6.00	4.00	1.00	2.00		1.00	1.00	2.00
T19	5.00	2.00	1.00	2.00		1.00		1.00
T20	4.00	2.00	1.00	2.00		1.00		1.00
T21	4.00	2.00	1.00	2.00				1.00
T22	2.00		1.00	2.00				1.00
T23	2.00			2.00				1.00
T24	1.00			1.00				

+	R652.BASE	R674.BASE
T06		2.00
T07	1.00	1.00
T08	1.00	
T15	1.00	
T16	1.00	2.00
T17	1.00	1.00
T18	1.00	

INDEX 1 = B16

	R025.BASE	R050.BASE	R649.BASE	R766.BASE
T05				3.00
T06		1.00	2.00	4.00
T07	1.00	2.00	2.00	12.00
T08		1.00	1.00	5.00
T09				1.00
T10		1.00		
T11				1.00
T12		1.00		1.00
T13		1.00		1.00
T14		2.00		1.00
T15	2.00	2.00	1.00	2.00
T16	2.00	2.00	2.00	2.00
T17	1.00	2.00	2.00	1.00
T18	1.00	1.00	1.00	1.00
T19				1.00
T20				1.00

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758 PARAMETER RTBL06 VEHICLE OPERATING ACTIVITIES FOR EACH VEHICLE

INDEX 1 = B17

	R250.BASE
T05	1.00
T06	3.00
T07	12.00
T08	6.00
T15	5.00
T16	11.00
T17	5.00
T18	2.00

INDEX 1 = B21

	R004.BASE	R005.BASE	R007.BASE	R010.BASE	R014.BASE	R016.BASE	R019.BASE	R022.BASE
T05		3.00	1.00		3.00		2.00	3.00
T06		6.00	1.00		4.00		3.00	4.00
T07		8.00	1.00		4.00		3.00	5.00
T08		8.00	1.00		4.00		3.00	5.00
T09		8.00	1.00		3.00		3.00	4.00
T10		8.00	1.00	1.00	4.00		3.00	3.00
T11		8.00	1.00	1.00	3.00		3.00	3.00
T12		8.00	1.00	1.00	3.00		3.00	3.00
T13		8.00	1.00	1.00	3.00		3.00	3.00
T14		8.00	1.00	1.00	4.00		3.00	3.00
T15	1.00	8.00	1.00		4.00		3.00	4.00
T16	2.00	8.00	1.00		4.00		3.00	4.00
T17	2.00	7.00	1.00		4.00		3.00	4.00
T18	2.00	6.00	1.00	2.00	3.00	2.00	3.00	3.00
T19	2.00	6.00	1.00	3.00	3.00	2.00	3.00	2.00
T20	2.00	4.00	1.00	3.00	2.00	2.00	3.00	2.00
T21	2.00	4.00	1.00	3.00	2.00	1.00	3.00	2.00
T22	2.00	4.00	1.00	2.00	2.00	1.00	3.00	2.00
T23	2.00	3.00	1.00	2.00	2.00	1.00	2.00	2.00
T24	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

+	R025.BASE	R675.BASE
T05	1.00	1.00
T06	1.00	2.00
T07	1.00	2.00
T08	1.00	2.00
T09	1.00	2.00
T10	1.00	2.00
T11	1.00	2.00
T12	1.00	2.00
T13	1.00	2.00
T14	1.00	2.00
T15		2.00
T16		2.00
T17		2.00
T19		1.00
T20		1.00
T21		1.00
T22		1.00

INDEX 1 = B22

	R005.BASE	R016.BASE	R250.BASE
T05			1.00
T06			1.00
T07			1.00
T08			1.00
T10	1.00		

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758 PARAMETER RTBL06 VEHICLE OPERATING ACTIVITIES FOR EACH VEHICLE

INDEX 1 = B22

	R005.BASE	R016.BASE	R250.BASE
T13			1.00
T14			1.00
T15			1.00
T16			1.00
T17			1.00
T18			1.00
T19			1.00
T21		1.00	
T22		1.00	
T23		1.00	
T24		1.00	

INDEX 1 = B23

	R010.BASE	R094.BASE	R667.BASE	R672.BASE
T05	3.00	2.00	1.00	
T06	4.00	5.00	4.00	2.00
T07	5.00	6.00	3.00	2.00
T08	5.00	3.00	1.00	1.00
T09	5.00	1.00	1.00	
T10	4.00	1.00		
T11	4.00	1.00		
T12	4.00	1.00		
T13	4.00	1.00		
T14	4.00	2.00		
T15	5.00	3.00	2.00	1.00
T16	6.00	4.00	4.00	2.00
T17	5.00	4.00	3.00	1.00
T18	2.00	3.00	1.00	1.00
T19	1.00			

INDEX 1 = B26

	R094.BASE
T05	1.00
T06	1.00
T07	1.00
T08	1.00
T09	1.00
T10	1.00
T11	1.00
T12	1.00
T13	1.00
T14	1.00
T15	1.00
T16	1.00
T17	1.00
T18	1.00
T19	1.00
T20	1.00
T21	1.00
T22	1.00
T23	1.00
T24	1.00

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758 PARAMETER RTBL06 VEHICLE OPERATING ACTIVITIES FOR EACH VEHICLE

INDEX 1 = B28

	R003.BASE	R007.BASE	R016.BASE	R018.BASE	R019.BASE
T05				3.00	
T06				5.00	2.00
T07	2.00			8.00	3.00
T08				8.00	3.00
T09				8.00	3.00
T10				8.00	3.00
T11				8.00	3.00
T12				8.00	3.00
T13				8.00	3.00
T14			1.00	8.00	3.00
T15	1.00		1.00	8.00	3.00
T16	3.00	1.00	2.00	8.00	3.00
T17	3.00		2.00	8.00	3.00
T18				7.00	2.00
T19				7.00	2.00
T20				5.00	1.00
T21				4.00	
T22				4.00	
T23				3.00	
T24				3.00	

---- 762 PARAMETER RTBL07 VEHICLE OPERATING ACTIVITIES ON ALL ROUTES

	B06	B14	B15	B16	B17	B21	B22	B23
T05			14.00	3.00	1.00	14.00	1.00	6.00
T06			19.00	7.00	3.00	21.00	1.00	15.00
T07			23.00	17.00	12.00	24.00	1.00	16.00
T08		1.00	20.00	7.00	6.00	24.00	1.00	10.00
T09		1.00	19.00	1.00		22.00		7.00
T10			17.00	1.00		23.00	1.00	5.00
T11			18.00	1.00		22.00		5.00
T12			19.00	2.00		22.00		5.00
T13	1.00		18.00	2.00		22.00	1.00	5.00
T14			21.00	3.00		23.00	1.00	6.00
T15			23.00	7.00	5.00	23.00	1.00	11.00
T16			23.00	8.00	11.00	24.00	1.00	16.00
T17			23.00	6.00	5.00	23.00	1.00	13.00
T18	1.00		18.00	4.00	2.00	22.00	1.00	7.00
T19			12.00	1.00		23.00	1.00	1.00
T20			11.00	1.00		20.00		
T21			10.00			19.00	1.00	
T22			6.00			18.00	1.00	
T23			5.00			15.00	1.00	
T24			2.00			8.00	1.00	

+	B26	B28
T05	1.00	3.00
T06	1.00	7.00
T07	1.00	13.00
T08	1.00	11.00
T09	1.00	11.00
T10	1.00	11.00
T11	1.00	11.00
T12	1.00	11.00
T13	1.00	11.00
T14	1.00	12.00
T15	1.00	13.00
T16	1.00	17.00
T17	1.00	16.00
T18	1.00	9.00

762 PARAMETER RTBL07 VEHICLE OPERATING ACTIVITIES ON ALL ROUTES

+	B26	B28
T19	1.00	9.00
T20	1.00	6.00
T21	1.00	4.00
T22	1.00	4.00
T23	1.00	3.00
T24	1.00	3.00

---- 769 PARAMETER RTBL08 INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITIES AND BOUNDS

INDEX 1 = DIESEL

	PRICE	LEVEL	UPPER
T04	3.141	36.383	+INF
T05	3.141	170.645	+INF
T06	3.141	292.081	+INF
T07	3.141	504.774	+INF
T08	3.141	336.753	+INF
T09	3.141	179.105	+INF
T10	3.141	150.884	+INF
T11	3.141	149.880	+INF
T12	3.141	153.901	+INF
T13	3.141	172.064	+INF
T14	3.141	196.244	+INF
T15	3.141	320.160	+INF
T16	3.141	442.012	+INF
T17	3.141	329.596	+INF
T18	3.141	231.865	+INF
T19	3.141	142.253	+INF
T20	3.141	105.083	+INF
T21	3.141	84.211	+INF
T22	3.141	74.363	+INF
T23	3.141	63.479	+INF
T24	3.141	45.938	+INF
T25	3.141	12.890	+INF

INDEX 1 = MAINT

	PRICE	LEVEL	UPPER
T04	1.000	5.804	+INF
T05	1.000	40.293	+INF
T06	1.000	63.456	+INF
T07	1.000	88.036	+INF
T08	1.000	70.146	+INF
T09	1.000	53.664	+INF
T10	1.000	49.974	+INF
T11	1.000	47.827	+INF
T12	1.000	48.771	+INF
T13	1.000	52.458	+INF
T14	1.000	57.772	+INF
T15	1.000	71.426	+INF
T16	1.000	82.873	+INF
T17	1.000	74.148	+INF
T18	1.000	58.095	+INF
T19	1.000	42.958	+INF
T20	1.000	33.588	+INF
T21	1.000	30.793	+INF
T22	1.000	26.843	+INF
T23	1.000	23.081	+INF
T24	1.000	16.241	+INF
T25	1.000	2.244	+INF

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----   773 PARAMETER RTBL09 INPUT OR RESOURCE PURCHASE OR SUPPLY ACTIVITIES

	DIESEL	MAINT
T04	36.383	5.804
T05	170.645	40.293
T06	292.081	63.456
T07	504.774	88.036
T08	336.753	70.146
T09	179.105	53.664
T10	150.884	49.974
T11	149.880	47.827
T12	153.901	48.771
T13	172.064	52.458
T14	196.244	57.772
T15	320.160	71.426
T16	442.012	82.873
T17	329.596	74.148
T18	231.865	58.095
T19	142.253	42.958
T20	105.083	33.588
T21	84.211	30.793
T22	74.363	26.843
T23	63.479	23.081
T24	45.938	16.241
T25	12.890	2.244

----   779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R003 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	24.003	114.000	+INF
T06	28.258	152.000	+INF
T07	66.516	228.000	+INF
T08	45.468	152.000	+INF
T09	40.974	152.000	+INF
T10	39.579	152.000	+INF
T11	31.900	190.000	+INF
T12	40.623	228.000	+INF
T13	55.076	228.000	+INF
T14	66.735	228.000	+INF
T15	50.633	266.000	+INF
T16	73.337	304.000	+INF
T17	80.653	342.000	+INF
T18	50.495	228.000	+INF
T19	41.152	190.000	+INF
T20	35.321	152.000	+INF
T21	37.208	152.000	+INF
T22	34.856	76.000	+INF
T23	24.319	76.000	+INF
T24	17.082	38.000	+INF
T25			+INF

INDEX 1 = R003 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	3.000	3.000	+INF
T06	4.000	4.000	+INF
T07	6.000	6.000	+INF
T08	4.000	4.000	+INF
T09	4.000	4.000	+INF
T10	4.000	4.000	+INF
T11	5.000	5.000	+INF

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R003 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T12	6.000	6.000	+INF
T13	6.000	6.000	+INF
T14	6.000	6.000	+INF
T15	7.000	7.000	+INF
T16	8.000	8.000	+INF
T17	9.000	9.000	+INF
T18	6.000	6.000	+INF
T19	5.000	5.000	+INF
T20	4.000	4.000	+INF
T21	4.000	4.000	+INF
T22	2.000	2.000	+INF
T23	2.000	2.000	+INF
T24	1.000	1.000	+INF
T25			+INF

INDEX 1 = R004 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	16.974	114.000	+INF
T06	20.255	114.000	+INF
T07	41.829	152.000	+INF
T08	32.439	152.000	+INF
T09	25.818	190.000	+INF
T10	26.092	152.000	+INF
T11	29.980	152.000	+INF
T12	26.784	152.000	+INF
T13	31.178	152.000	+INF
T14	34.832	228.000	+INF
T15	27.533	266.000	+INF
T16	27.986	304.000	+INF
T17	53.621	342.000	+INF
T18	40.330	228.000	+INF
T19	26.129	152.000	+INF
T20	18.795	152.000	+INF
T21	11.361	152.000	+INF
T22	19.868	76.000	+INF
T23	15.546	76.000	+INF
T24	15.864	38.000	+INF
T25			+INF

INDEX 1 = R004 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	3.000	3.000	+INF
T06	3.000	3.000	+INF
T07	4.000	4.000	+INF
T08	4.000	4.000	+INF
T09	5.000	5.000	+INF
T10	4.000	4.000	+INF
T11	4.000	4.000	+INF
T12	4.000	4.000	+INF
T13	4.000	4.000	+INF
T14	6.000	6.000	+INF
T15	7.000	7.000	+INF
T16	8.000	8.000	+INF
T17	9.000	9.000	+INF
T18	6.000	6.000	+INF
T19	4.000	4.000	+INF
T20	4.000	4.000	+INF

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779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R004 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T21	4.000	4.000	+INF
T22	2.000	2.000	+INF
T23	2.000	2.000	+INF
T24	1.000	1.000	+INF
T25			+INF

INDEX 1 = R005 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	25.511	114.000	+INF
T06	25.660	228.000	+INF
T07	48.704	304.000	+INF
T08	51.679	304.000	+INF
T09	40.425	304.000	+INF
T10	21.016	344.000	+INF
T11	51.096	304.000	+INF
T12	82.193	304.000	+INF
T13	31.426	304.000	+INF
T14	51.989	304.000	+INF
T15	62.792	304.000	+INF
T16	42.294	304.000	+INF
T17	41.604	266.000	+INF
T18	20.147	228.000	+INF
T19	29.264	228.000	+INF
T20	28.877	152.000	+INF
T21	29.500	152.000	+INF
T22	23.571	152.000	+INF
T23	18.000	114.000	+INF
T24	15.528	38.000	+INF
T25			+INF

INDEX 1 = R005 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	3.000	3.000	+INF
T06	6.000	6.000	+INF
T07	8.000	8.000	+INF
T08	8.000	8.000	+INF
T09	8.000	8.000	+INF
T10	9.000	9.000	+INF
T11	8.000	8.000	+INF
T12	8.000	8.000	+INF
T13	8.000	8.000	+INF
T14	8.000	8.000	+INF
T15	8.000	8.000	+INF
T16	8.000	8.000	+INF
T17	7.000	7.000	+INF
T18	6.000	6.000	+INF
T19	6.000	6.000	+INF
T20	4.000	4.000	+INF
T21	4.000	4.000	+INF
T22	4.000	4.000	+INF
T23	3.000	3.000	+INF
T24	1.000	1.000	+INF
T25			+INF

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779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R007 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	8.534	76.000	+INF
T06	18.979	76.000	+INF
T07	17.197	76.000	+INF
T08	21.362	76.000	+INF
T09	26.424	76.000	+INF
T10	17.549	76.000	+INF
T11	17.248	76.000	+INF
T12	18.593	76.000	+INF
T13	17.186	76.000	+INF
T14	24.274	76.000	+INF
T15	22.702	76.000	+INF
T16	26.360	114.000	+INF
T17	25.016	76.000	+INF
T18	15.661	76.000	+INF
T19	15.196	76.000	+INF
T20	9.283	76.000	+INF
T21	7.886	76.000	+INF
T22	6.656	76.000	+INF
T23		38.000	+INF
T24	5.630	38.000	+INF
T25			+INF

INDEX 1 = R007 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	2.000	2.000	+INF
T06	2.000	2.000	+INF
T07	2.000	2.000	+INF
T08	2.000	2.000	+INF
T09	2.000	2.000	+INF
T10	2.000	2.000	+INF
T11	2.000	2.000	+INF
T12	2.000	2.000	+INF
T13	2.000	2.000	+INF
T14	2.000	2.000	+INF
T15	2.000	2.000	+INF
T16	3.000	3.000	+INF
T17	2.000	2.000	+INF
T18	2.000	2.000	+INF
T19	2.000	2.000	+INF
T20	2.000	2.000	+INF
T21	2.000	2.000	+INF
T22	2.000	2.000	+INF
T23	1.000	1.000	+INF
T24	1.000	1.000	+INF
T25			+INF

INDEX 1 = R009 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	13.337	76.000	+INF
T06	18.094	76.000	+INF
T07	28.227	152.000	+INF
T08	23.991	114.000	+INF
T09	22.389	76.000	+INF
T10	21.005	76.000	+INF
T11	22.669	76.000	+INF
T12	34.586	76.000	+INF

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779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R009 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T13	26.004	76.000	+INF
T14	20.369	114.000	+INF
T15	28.138	114.000	+INF
T16	32.091	114.000	+INF
T17	28.685	76.000	+INF
T18	14.814	76.000	+INF
T19	14.399	76.000	+INF
T20	15.089	76.000	+INF
T21	12.609	76.000	+INF
T22	12.738	76.000	+INF
T23	9.298	76.000	+INF
T24	4.750	38.000	+INF
T25			+INF

INDEX 1 = R009 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	2.000	2.000	+INF
T06	2.000	2.000	+INF
T07	4.000	4.000	+INF
T08	3.000	3.000	+INF
T09	2.000	2.000	+INF
T10	2.000	2.000	+INF
T11	2.000	2.000	+INF
T12	2.000	2.000	+INF
T13	2.000	2.000	+INF
T14	3.000	3.000	+INF
T15	3.000	3.000	+INF
T16	3.000	3.000	+INF
T17	2.000	2.000	+INF
T18	2.000	2.000	+INF
T19	2.000	2.000	+INF
T20	2.000	2.000	+INF
T21	2.000	2.000	+INF
T22	2.000	2.000	+INF
T23	2.000	2.000	+INF
T24	1.000	1.000	+INF
T25			+INF

INDEX 1 = R010 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	51.096	152.000	+INF
T06	71.411	190.000	+INF
T07	125.337	228.000	+INF
T08	126.868	228.000	+INF
T09	122.755	228.000	+INF
T10	123.201	228.000	+INF
T11	118.876	228.000	+INF
T12	144.749	228.000	+INF
T13	154.144	228.000	+INF
T14	165.217	228.000	+INF
T15	170.645	228.000	+INF
T16	167.697	228.000	+INF
T17	119.102	190.000	+INF
T18	121.638	152.000	+INF
T19	85.793	152.000	+INF
T20	76.842	114.000	+INF
T21	59.992	114.000	+INF

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R010 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T22	53.335	76.000	+INF
T23	45.413	76.000	+INF
T24	14.197	38.000	+INF
T25			+INF

INDEX 1 = R010 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	4.000	4.000	+INF
T06	5.000	5.000	+INF
T07	6.000	6.000	+INF
T08	6.000	6.000	+INF
T09	6.000	6.000	+INF
T10	6.000	6.000	+INF
T11	6.000	6.000	+INF
T12	6.000	6.000	+INF
T13	6.000	6.000	+INF
T14	6.000	6.000	+INF
T15	6.000	6.000	+INF
T16	6.000	6.000	+INF
T17	5.000	5.000	+INF
T18	4.000	4.000	+INF
T19	4.000	4.000	+INF
T20	3.000	3.000	+INF
T21	3.000	3.000	+INF
T22	2.000	2.000	+INF
T23	1.000	2.000	+INF
T24	1.000	1.000	+INF
T25			+INF

INDEX 1 = R014 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	8.905	114.000	+INF
T06	15.447	152.000	+INF
T07	16.280	152.000	+INF
T08	28.463	152.000	+INF
T09	32.534	114.000	+INF
T10	28.865	152.000	+INF
T11	17.429	114.000	+INF
T12	19.785	114.000	+INF
T13	31.928	114.000	+INF
T14	34.581	152.000	+INF
T15	51.426	152.000	+INF
T16	52.271	152.000	+INF
T17	31.544	152.000	+INF
T18	22.127	114.000	+INF
T19	23.093	114.000	+INF
T20	18.970	76.000	+INF
T21	19.812	76.000	+INF
T22	22.446	76.000	+INF
T23	7.589	76.000	+INF
T24	13.496	38.000	+INF
T25			+INF

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779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R014 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	3.000	3.000	+INF
T06	4.000	4.000	+INF
T07	4.000	4.000	+INF
T08	4.000	4.000	+INF
T09	3.000	3.000	+INF
T10	4.000	4.000	+INF
T11	3.000	3.000	+INF
T12	3.000	3.000	+INF
T13	3.000	3.000	+INF
T14	4.000	4.000	+INF
T15	4.000	4.000	+INF
T16	4.000	4.000	+INF
T17	4.000	4.000	+INF
T18	3.000	3.000	+INF
T19	3.000	3.000	+INF
T20	2.000	2.000	+INF
T21	2.000	2.000	+INF
T22	2.000	2.000	+INF
T23	2.000	2.000	+INF
T24	1.000	1.000	+INF
T25			+INF

INDEX 1 = R016 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	20.819	76.000	+INF
T06	36.588	114.000	+INF
T07	74.693	114.000	+INF
T08	87.806	114.000	+INF
T09	96.122	114.000	+INF
T10	92.015	114.000	+INF
T11	109.473	114.000	+INF
T12	83.306	114.000	+INF
T13	116.862	119.000	+INF
T14	66.814	114.000	+INF
T15	82.575	114.000	+INF
T16	39.538	114.000	+INF
T17	68.159	114.000	+INF
T18	67.130	114.000	+INF
T19	42.412	114.000	+INF
T20	70.917	114.000	+INF
T21	44.175	78.000	+INF
T22	39.194	78.000	+INF
T23	27.255	78.000	+INF
T24	27.433	78.000	+INF
T25			+INF

INDEX 1 = R016 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	2.000	2.000	+INF
T06	3.000	3.000	+INF
T07	3.000	3.000	+INF
T08	3.000	3.000	+INF
T09	3.000	3.000	+INF
T10	3.000	3.000	+INF
T11	3.000	3.000	+INF
T12	3.000	3.000	+INF

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        779 PARAMETER RTBL10  SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R016  INDEX 2 = FREQ

          LOWER       LEVEL       UPPER

T13       3.000       3.000        +INF
T14       3.000       3.000        +INF
T15       3.000       3.000        +INF
T16       3.000       3.000        +INF
T17       3.000       3.000        +INF
T18       3.000       3.000        +INF
T19       3.000       3.000        +INF
T20       3.000       3.000        +INF
T21       2.000       2.000        +INF
T22       2.000       2.000        +INF
T23       2.000       2.000        +INF
T24       2.000       2.000        +INF
T25                                +INF

INDEX 1 = R018  INDEX 2 = TSEAT

          LOWER       LEVEL       UPPER

T04                                +INF
T05      27.875     114.000        +INF
T06      22.542     190.000        +INF
T07      18.812     304.000        +INF
T08      19.661     304.000        +INF
T09      29.074     304.000        +INF
T10      26.708     304.000        +INF
T11      30.042     304.000        +INF
T12      50.333     304.000        +INF
T13      44.146     304.000        +INF
T14      49.146     304.000        +INF
T15      52.750     304.000        +INF
T16      34.583     304.000        +INF
T17      30.062     304.000        +INF
T18      25.833     266.000        +INF
T19      33.771     266.000        +INF
T20      20.646     190.000        +INF
T21      17.625     152.000        +INF
T22      18.208     152.000        +INF
T23      16.187     114.000        +INF
T24      10.375     114.000        +INF
T25                                +INF

INDEX 1 = R018  INDEX 2 = FREQ

          LOWER       LEVEL       UPPER

T04                                +INF
T05       3.000       3.000        +INF
T06       5.000       5.000        +INF
T07       8.000       8.000        +INF
T08       8.000       8.000        +INF
T09       8.000       8.000        +INF
T10       8.000       8.000        +INF
T11       8.000       8.000        +INF
T12       8.000       8.000        +INF
T13       8.000       8.000        +INF
T14       8.000       8.000        +INF
T15       8.000       8.000        +INF
T16       8.000       8.000        +INF
T17       8.000       8.000        +INF
T18       7.000       7.000        +INF
T19       7.000       7.000        +INF
T20       5.000       5.000        +INF
T21       4.000       4.000        +INF
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779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R018 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T22	4.000	4.000	+INF
T23	3.000	3.000	+INF
T24	3.000	3.000	+INF
T25			+INF

INDEX 1 = R019 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	17.018	76.000	+INF
T06	38.878	190.000	+INF
T07	97.040	228.000	+INF
T08	37.734	228.000	+INF
T09	48.220	228.000	+INF
T10	39.838	228.000	+INF
T11	47.434	228.000	+INF
T12	46.632	228.000	+INF
T13	51.005	228.000	+INF
T14	53.843	228.000	+INF
T15	75.001	228.000	+INF
T16	51.742	228.000	+INF
T17	42.815	228.000	+INF
T18	58.090	190.000	+INF
T19	39.152	190.000	+INF
T20	32.181	152.000	+INF
T21	47.800	114.000	+INF
T22	33.957	114.000	+INF
T23	22.451	76.000	+INF
T24		38.000	+INF
T25			+INF

INDEX 1 = R019 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	2.000	2.000	+INF
T06	5.000	5.000	+INF
T07	6.000	6.000	+INF
T08	6.000	6.000	+INF
T09	6.000	6.000	+INF
T10	6.000	6.000	+INF
T11	6.000	6.000	+INF
T12	6.000	6.000	+INF
T13	6.000	6.000	+INF
T14	6.000	6.000	+INF
T15	6.000	6.000	+INF
T16	6.000	6.000	+INF
T17	6.000	6.000	+INF
T18	5.000	5.000	+INF
T19	5.000	5.000	+INF
T20	4.000	4.000	+INF
T21	3.000	3.000	+INF
T22	3.000	3.000	+INF
T23	2.000	2.000	+INF
T24	1.000	1.000	+INF
T25			+INF

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779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R022 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	15.061	114.000	+INF
T06	21.037	152.000	+INF
T07	49.492	190.000	+INF
T08	41.458	190.000	+INF
T09	31.070	152.000	+INF
T10	31.645	114.000	+INF
T11	43.360	114.000	+INF
T12	38.597	114.000	+INF
T13	37.938	114.000	+INF
T14	37.331	114.000	+INF
T15	48.199	152.000	+INF
T16	50.395	152.000	+INF
T17	28.604	152.000	+INF
T18	26.005	114.000	+INF
T19	24.664	76.000	+INF
T20	37.394	76.000	+INF
T21	28.679	76.000	+INF
T22	28.143	76.000	+INF
T23	21.508	76.000	+INF
T24	12.263	38.000	+INF
T25			+INF

INDEX 1 = R022 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	3.000	3.000	+INF
T06	4.000	4.000	+INF
T07	5.000	5.000	+INF
T08	5.000	5.000	+INF
T09	4.000	4.000	+INF
T10	3.000	3.000	+INF
T11	3.000	3.000	+INF
T12	3.000	3.000	+INF
T13	3.000	3.000	+INF
T14	3.000	3.000	+INF
T15	4.000	4.000	+INF
T16	4.000	4.000	+INF
T17	4.000	4.000	+INF
T18	3.000	3.000	+INF
T19	2.000	2.000	+INF
T20	2.000	2.000	+INF
T21	2.000	2.000	+INF
T22	2.000	2.000	+INF
T23	2.000	2.000	+INF
T24	1.000	1.000	+INF
T25			+INF

INDEX 1 = R025 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	24.140	38.000	+INF
T06	21.184	76.000	+INF
T07	58.530	114.000	+INF
T08	34.751	76.000	+INF
T09	20.582	76.000	+INF
T10	15.938	38.000	+INF
T11	15.174	38.000	+INF
T12	15.954	38.000	+INF

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R025 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T13	18.849	38.000	+INF
T14	21.115	38.000	+INF
T15	36.001	76.000	+INF
T16	46.931	76.000	+INF
T17	25.480	38.000	+INF
T18	19.553	76.000	+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R025 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	1.000	1.000	+INF
T06	2.000	2.000	+INF
T07	3.000	3.000	+INF
T08	2.000	2.000	+INF
T09	2.000	2.000	+INF
T10	1.000	1.000	+INF
T11	1.000	1.000	+INF
T12	1.000	1.000	+INF
T13	1.000	1.000	+INF
T14	1.000	1.000	+INF
T15	2.000	2.000	+INF
T16	2.000	2.000	+INF
T17	1.000	1.000	+INF
T18	2.000	2.000	+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R050 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05			+INF
T06	15.328	38.000	+INF
T07	59.088	76.000	+INF
T08	83.528	96.000	+INF
T09	50.833	58.000	+INF
T10	10.873	38.000	+INF
T11			+INF
T12	28.499	38.000	+INF
T13	13.588	38.000	+INF
T14	69.564	76.000	+INF
T15	74.689	76.000	+INF
T16	70.125	76.000	+INF
T17	64.063	76.000	+INF
T18	32.218	38.000	+INF
T19			+INF
T20			+INF
T21			+INF

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R050 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R050 INDEX 2 = FREQ

	LEVEL	UPPER
T04		+INF
T05		+INF
T06	1.000	+INF
T07	2.000	+INF
T08	2.000	+INF
T09	1.000	+INF
T10	1.000	+INF
T11		+INF
T12	1.000	+INF
T13	1.000	+INF
T14	2.000	+INF
T15	2.000	+INF
T16	2.000	+INF
T17	2.000	+INF
T18	1.000	+INF
T19		+INF
T20		+INF
T21		+INF
T22		+INF
T23		+INF
T24		+INF
T25		+INF

INDEX 1 = R061 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	10.374	76.000	+INF
T06	25.694	76.000	+INF
T07	36.580	114.000	+INF
T08	24.216	76.000	+INF
T09	29.200	76.000	+INF
T10	15.357	76.000	+INF
T11	16.029	76.000	+INF
T12	29.862	76.000	+INF
T13	17.866	76.000	+INF
T14	23.547	76.000	+INF
T15	42.664	114.000	+INF
T16	33.535	152.000	+INF
T17	45.102	152.000	+INF
T18	26.158	76.000	+INF
T19	18.551	38.000	+INF
T20	17.691	38.000	+INF
T21	14.909	38.000	+INF
T22	10.352	38.000	+INF
T23		38.000	+INF
T24			+INF
T25			+INF

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R061 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	2.000	2.000	+INF
T06	2.000	2.000	+INF
T07	3.000	3.000	+INF
T08	2.000	2.000	+INF
T09	2.000	2.000	+INF
T10	2.000	2.000	+INF
T11	2.000	2.000	+INF
T12	2.000	2.000	+INF
T13	2.000	2.000	+INF
T14	2.000	2.000	+INF
T15	3.000	3.000	+INF
T16	4.000	4.000	+INF
T17	4.000	4.000	+INF
T18	2.000	2.000	+INF
T19	1.000	1.000	+INF
T20	1.000	1.000	+INF
T21	1.000	1.000	+INF
T22	1.000	1.000	+INF
T23	1.000	1.000	+INF
T24			+INF
T25			+INF

INDEX 1 = R094 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	15.883	116.000	+INF
T06	30.175	230.000	+INF
T07	61.469	268.000	+INF
T08	41.038	154.000	+INF
T09	27.784	78.000	+INF
T10	21.713	78.000	+INF
T11	23.943	78.000	+INF
T12	37.080	78.000	+INF
T13	30.261	78.000	+INF
T14	37.087	116.000	+INF
T15	35.879	154.000	+INF
T16	110.191	192.000	+INF
T17	54.751	192.000	+INF
T18	30.511	154.000	+INF
T19	28.218	40.000	+INF
T20	22.671	40.000	+INF
T21	22.410	40.000	+INF
T22	35.375	40.000	+INF
T23	13.550	40.000	+INF
T24	7.531	40.000	+INF
T25			+INF

INDEX 1 = R094 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	3.000	3.000	+INF
T06	6.000	6.000	+INF
T07	7.000	7.000	+INF
T08	4.000	4.000	+INF
T09	2.000	2.000	+INF
T10	2.000	2.000	+INF
T11	2.000	2.000	+INF
T12	2.000	2.000	+INF

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R094 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T13	2.000	2.000	+INF
T14	3.000	3.000	+INF
T15	4.000	4.000	+INF
T16	5.000	5.000	+INF
T17	5.000	5.000	+INF
T18	4.000	4.000	+INF
T19	1.000	1.000	+INF
T20		1.000	+INF
T21		1.000	+INF
T22		1.000	+INF
T23		1.000	+INF
T24		1.000	+INF
T25			+INF

INDEX 1 = R250 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05		98.000	+INF
T06	43.176	214.000	+INF
T07	44.825	736.000	+INF
T08		388.000	+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13		40.000	+INF
T14		40.000	+INF
T15	39.511	330.000	+INF
T16	41.606	678.000	+INF
T17	33.798	330.000	+INF
T18	36.402	156.000	+INF
T19	14.565	40.000	+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R250 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	2.000	2.000	+INF
T06	4.000	4.000	+INF
T07	13.000	13.000	+INF
T08	7.000	7.000	+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13	1.000	1.000	+INF
T14	1.000	1.000	+INF
T15	6.000	6.000	+INF
T16	12.000	12.000	+INF
T17	6.000	6.000	+INF
T18	3.000	3.000	+INF
T19	1.000	1.000	+INF
T20			+INF
T21			+INF

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E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R250 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R649 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05			+INF
T06	9.527	76.000	+INF
T07	22.181	76.000	+INF
T08	14.362	38.000	+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13			+INF
T14			+INF
T15	18.223	38.000	+INF
T16	20.833	76.000	+INF
T17	15.946	76.000	+INF
T18	9.427	38.000	+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R649 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05			+INF
T06	2.000	2.000	+INF
T07	2.000	2.000	+INF
T08	1.000	1.000	+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13			+INF
T14			+INF
T15		1.000	+INF
T16	2.000	2.000	+INF
T17	2.000	2.000	+INF
T18	1.000	1.000	+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R652 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05			+INF
T06			+INF
T07		38.000	+INF
T08		38.000	+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13			+INF
T14			+INF
T15	23.714	38.000	+INF
T16	14.869	38.000	+INF
T17	19.988	38.000	+INF
T18	12.954	38.000	+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R652 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05			+INF
T06			+INF
T07	1.000	1.000	+INF
T08	1.000	1.000	+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13			+INF
T14			+INF
T15		1.000	+INF
T16	1.000	1.000	+INF
T17	1.000	1.000	+INF
T18		1.000	+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R667 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05		38.000	+INF
T06	30.320	152.000	+INF
T07	76.891	114.000	+INF
T08		38.000	+INF
T09	13.113	38.000	+INF
T10			+INF
T11			+INF
T12			+INF

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R667 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T13			+INF
T14			+INF
T15	18.035	76.000	+INF
T16	40.326	152.000	+INF
T17	53.801	114.000	+INF
T18	15.232	38.000	+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R667 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	1.000	1.000	+INF
T06	4.000	4.000	+INF
T07	3.000	3.000	+INF
T08	1.000	1.000	+INF
T09	1.000	1.000	+INF
T10			+INF
T11			+INF
T12			+INF
T13			+INF
T14			+INF
T15	2.000	2.000	+INF
T16	4.000	4.000	+INF
T17	3.000	3.000	+INF
T18	1.000	1.000	+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R672 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05			+INF
T06	5.559	76.000	+INF
T07	20.124	76.000	+INF
T08	16.442	38.000	+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13			+INF
T14			+INF
T15		38.000	+INF
T16	22.708	76.000	+INF
T17	9.796	38.000	+INF
T18		38.000	+INF
T19			+INF
T20			+INF
T21			+INF

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E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R672 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R672 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05			+INF
T06	2.000	2.000	+INF
T07	2.000	2.000	+INF
T08	1.000	1.000	+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13			+INF
T14			+INF
T15	1.000	1.000	+INF
T16	2.000	2.000	+INF
T17	1.000	1.000	+INF
T18	1.000	1.000	+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R674 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05			+INF
T06	23.460	76.000	+INF
T07		38.000	+INF
T08			+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13			+INF
T14			+INF
T15			+INF
T16		76.000	+INF
T17	15.145	38.000	+INF
T18			+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R674 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05			+INF
T06	2.000	2.000	+INF
T07	1.000	1.000	+INF
T08			+INF
T09			+INF
T10			+INF
T11			+INF
T12			+INF
T13			+INF
T14			+INF
T15			+INF
T16	2.000	2.000	+INF
T17	1.000	1.000	+INF
T18			+INF
T19			+INF
T20			+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R675 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05	11.602	38.000	+INF
T06	38.026	76.000	+INF
T07	52.758	76.000	+INF
T08	26.294	76.000	+INF
T09	10.980	76.000	+INF
T10	37.401	76.000	+INF
T11	28.120	76.000	+INF
T12	8.013	76.000	+INF
T13	21.653	76.000	+INF
T14	27.858	76.000	+INF
T15		76.000	+INF
T16	31.086	76.000	+INF
T17	31.643	76.000	+INF
T18	41.650	43.000	+INF
T19	28.398	38.000	+INF
T20	19.789	38.000	+INF
T21	18.634	38.000	+INF
T22	15.953	38.000	+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R675 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05		1.000	+INF
T06	2.000	2.000	+INF
T07	2.000	2.000	+INF
T08	2.000	2.000	+INF
T09	2.000	2.000	+INF
T10	2.000	2.000	+INF
T11	2.000	2.000	+INF
T12	2.000	2.000	+INF

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TRANSIT-OP-V03 MULT OBJ MIP MODEL FOR TRANSIT SYSTEM PLANNING
E x e c u t i o n

779 PARAMETER RTBL10 SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R675 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T13	2.000	2.000	+INF
T14	2.000	2.000	+INF
T15	2.000	2.000	+INF
T16	2.000	2.000	+INF
T17	2.000	2.000	+INF
T18	1.000	1.000	+INF
T19	1.000	1.000	+INF
T20	1.000	1.000	+INF
T21	1.000	1.000	+INF
T22	1.000	1.000	+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R766 INDEX 2 = TSEAT

	LOWER	LEVEL	UPPER
T04			+INF
T05		114.000	+INF
T06	31.761	152.000	+INF
T07	22.855	456.000	+INF
T08	53.224	190.000	+INF
T09		38.000	+INF
T10			+INF
T11		38.000	+INF
T12	24.750	38.000	+INF
T13	18.100	38.000	+INF
T14		38.000	+INF
T15	42.964	76.000	+INF
T16	44.317	76.000	+INF
T17	23.846	38.000	+INF
T18	12.997	38.000	+INF
T19	25.761	38.000	+INF
T20	1.642	38.000	+INF
T21			+INF
T22			+INF
T23			+INF
T24			+INF
T25			+INF

INDEX 1 = R766 INDEX 2 = FREQ

	LOWER	LEVEL	UPPER
T04			+INF
T05	3.000	3.000	+INF
T06	4.000	4.000	+INF
T07	12.000	12.000	+INF
T08	5.000	5.000	+INF
T09	1.000	1.000	+INF
T10			+INF
T11	1.000	1.000	+INF
T12		1.000	+INF
T13	1.000	1.000	+INF
T14	1.000	1.000	+INF
T15	1.000	2.000	+INF
T16		2.000	+INF
T17	1.000	1.000	+INF
T18	1.000	1.000	+INF
T19	1.000	1.000	+INF
T20	1.000	1.000	+INF
T21			+INF

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E x e c u t i o n


        779 PARAMETER RTBL10  SERVICE OR DEMAND ATTRIBUTE LEVELS

INDEX 1 = R766  INDEX 2 = FREQ

          LOWER       LEVEL       UPPER

T22                                +INF
T23                                +INF
T24                                +INF
T25                                +INF


**** REPORT FILE SUMMARY

TRANSITR1 C:\Users\japland\Documents\gamsdir\projdir\TRANSITR1.CSV


EXECUTION TIME       =        0.157 SECONDS     93 MB  25.1.3 r4e34d435fbd WEX-WEI


USER: Small MUD - 5 User License                    G181031:1453AO-WIN
      University of Minnesota, Applied Economics                DC2963
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**** FILE SUMMARY

Input      C:\1 Research\Transit\TRANSIT-OP-V03 Doc Version Jan 2019.gms
Output     C:\Users\japland\Documents\gamsdir\projdir\TRANSIT-OP-V03 Doc Version Jan 2019.lst
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