Multipath Capacity-Limited Transit Assignment

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At present most patronage predictions of transit systems are performed using UMTA Transportation Planning System (UTPS) package or some adaptation of it. The transit assignment produced by a typical UTPS system can be classified as an all-or-nothing limited equilibrium assignment. However, passenger loads assigned to a transit line can far exceed the line capacity. In such a case line headway has to be reduced to provide enough capacity to accommodate transit demand. If the increase in frequency is not accounted for by iterating again through the mode choice and assignment models, the equilibrium assumptions are violated. If equilibrium between demand and supply is achieved, it might occur at a point that requires transit capacity much beyond economically feasible or engineering practical levels. Thus the present transit assignment procedure suffers from two problems. First, trips are assigned to transit lines without regard to their actual capacity. Second, while some lines are assigned passenger loads beyond capacity, there might be other lines with just slightly longer travel times that are greatly underutilized. A realistic assignment should take into account and not exceed the actual capacity of every transit line. Furthermore, it should consider lines' capacities while rationally simulating people's travel behavior. A transit assignment algorithm is presented that takes into account the actual capacity of transit lines and assigns trips to more than a single path when the shortest path reaches its capacity. This procedure produces a practical Multipath Capacity-Limited Transit Assignment (McLAT). The procedure was implemented on an IBM mainframe computer using the standard UTPS package with the addition of only one FORTRAN program.

At present most patronage predictions of transit systems are performed using the UMTA Transportation Planning System (UTPS) package (*1*) or some adaptation of it. This set of programs is typically applied once in a customary sequence of mode choice and assignment programs to produce ridership predictions for the various components of a transit system during typical periods of the day. The transit assignment produced by a typical UTPS application can be classified as an all-or-nothing limited equilibrium assignment. The equilibrium achieved by this type of assignment procedure under the usual assumptions of constant travel times and headways has the property that no individual using the system can improve his utility by using a different transit line or switching to a different mode.

However, passenger loads assigned to a transit line can far exceed the line capacity. In such a case line headway has to be reduced to provide enough capacity to accommodate transit demand. If the increase in frequency is not accounted for by iterating again through the mode choice and assignment models, the equilibrium assumptions are violated. If this iteration is performed, on the other hand, the new demand will be even higher, requiring more transit capacity. This process may or may not converge, but even if it does it might occur at an equilibrium point that requires transit capacity much beyond economically feasible levels. The equilibrium may even occur at a point that violates engineering constraints, such as street capacities or minimum headway separation between vehicles. Thus the presently used transit assignment program suffers from the following two undesirable and unrealistic characteristics:

1. Trips are assigned to transit lines with disregard to their actual capacity. Thus, some lines might be loaded with passengers much beyond their ability to carry those loads.
2. While some lines are assigned passenger loads beyond capacity, there might be other lines serving the same origin/destination (O/D) pairs with just slightly longer travel times that are greatly underutilized.

These two problems occur because of the simple all-or-nothing procedure used for transit assignment, and they have very serious practical implications on the validity of the transportation planning process. From the point of view of a transit agency, the amount of service that it can provide at a given future year is dictated by economic considerations and budget limitations. Thus, a clear planning objective for a transit agency is to achieve a realistic transit assignment for a given level of service. In this context, transit level of service should be treated as a predetermined policy decision, if not throughout the whole planning process, than at least in its final stages. Thus a realistic assignment should take into account and not exceed the actual capacity of every transit line. Furthermore, it should consider lines' capacity while rationally simulating people's travel behavior. A rational transit assignment model should take into account not only the fastest transit route serving an O/D pair, but should also consider second- or even third-best transit alternative options. The second- or third-best transit alternatives should be considered as long as the best option is overcrowded and the alternatives' travel utility is higher than the nontransit alternative.

In this paper we present a transit assignment algorithm that takes into account the actual capacity of transit lines and assigns trips to more than a single path when the shortest path reaches its capacity. This procedure produces a practical Multipath Capacity Limited Transit Assignment (McLAT). It was implemented on an IBM mainframe computer using the standard UTPS package with the addition of a single FORTRAN program and a minute modification of one existing program.

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In the following sections we discuss the theoretical background of the proposed algorithm within the UTPS framework and formally present the algorithm itself. Later sections provide an outline of programming considerations for the implementation of the algorithm and a comparison between proposed transit assignment and a standard UTPS procedure applied to the Los Angeles metropolitan area.

THEORETICAL BACKGROUND OF THE PROPOSED PROCEDURE

At present the typical UTPS process performs transit assignment assuming no limits on the capacity of transit lines. Thus the present transit assignment procedure is an all-or-nothing assignment, in the sense that for every O/D pair, all trips are assigned to a single transit path. This will happen even if the assigned passenger volumes far exceed the shortest line capacity and even if an alternative underutilized path exists between the same O/D pairs with only slightly longer travel times. The underlying behavioral assumption of the proposed McLAT procedure is that people will chose to use second- or third-best transit alternatives as long as these alternatives possess a higher utility than all other nontransit alternatives.

This assignment does not reach equilibrium in the transit network, because there are people using transit between the same O/D pairs who could improve their utility by switching to another transit path. However, in spite of the fact that transit equilibrium is not maintained, it will be shown next that equilibrium conditions exist between total demand for travel and supply. We argue that the proposed procedure is more realistic than the present ones, which neglect to realize economic or engineering capacity limits. On moderately crowded transit systems, the present assignment procedure might produce erroneous results. On very crowded transit systems, which are typical of rush-hour periods in large metropolitan areas, the results of existing transit assignment procedures might produce completely unrealistic patronage forecasts that greatly overestimate actual transit usage. A short discussion of the proposed McLAT algorithm with respect to equilibrium in the urban transportation system follows.

To begin the discussion, we adopt two basic assumptions that are customary within the framework of UTPS models system:

1. The characteristics of demand and supply are stationary for the simulated time period. This time period can be a whole day or any typical part of it.
2. The total travel demand on all modes for each O/D pair is fixed. Thus the O/D matrix is exogenous to the transportation modeling system.

These two assumptions narrow the equilibrium problem to the distribution of trips between the various network modes and routes. The demand function is a standard Logit function, while the supply function is determined by the transit and highway characteristics. The supply curve of a single transit line is not influenced by travel volumes, whereas travel time on the highway monotonically increases with volume. In the present application of the UTPS system it is assumed that the transit line does not have any capacity limits. However, it seems very unrealistic to assume no capacity limits on heavily crowded transit systems. If the shortest transit route serving a pair of zones has a specific capacity of passengers per hour, all excess demand has to use the highway network or some other transit path.

In the proposed McLAT procedure, we assume that any transit path that has excess capacity and provides the users with a higher travel utility than the highway system constitutes a feasible transit alternative and will be used for travel. This hierarchical choice process can be stated as follows: a zone pair is serviced by two or more transit lines with limited capacity. The supply functions of these lines are:

$$TT1 = \begin{Bmatrix} A & VT1 \leq CT1 \\ 0 & VT1 > CT1 \end{Bmatrix} \text{ and}$$

$$TT2 = \begin{Bmatrix} B & VT2 \leq CT2 \\ 0 & VT2 > CT2 \end{Bmatrix} \quad (1)$$

where

$CT1$ and $CT2$ = capacity limits of Lines 1 and 2;
$VT1$ and $VT2$ = passengers loads of Lines 1 and 2;
$TT1$ and $TT2$ = travel times of Lines 1 and 2, with $TT2 > TT1$.

The supply function for the highway network can be stated as:

$$TC = T0 + F(VC) \quad (2)$$

where $T0$ equals the free-flow travel time on the highway path and $F(VC)$ equals an increasing function of volume VC.

The equilibrium state for this system is presented in Figure 1. In the figure the demand function (D-D) is a simple Logit function, and the supply function (S-S) is defined as:

$$TC - TT1 = T0 + F(V - VT) - TT1 \quad (3)$$

where V is the total travel demand between a O/D pair. Since Line 1 is superior to Line 2, providing a shorter travel time, its travel time ($TT1$) is used in the supply equation. The potential demand for Line 1 is (VP), but its capacity is ($CT1$), and $VP > CT1$. Thus, the actual number of passengers who can use Line 1 is ($VC1$), producing unassigned demand of the magnitude of ($VP - CT1$). This demand cannot use Line 1 and has to choose between the highway and transit Line 2. This leftover demand can be split between the two modes using the original Logit function. The unassigned volume ($VP - CT1$) should be distributed between the highway and transit Line 2 as shown in Figure 2. The proposed procedure can be expanded to any number of lines serving the same O/D pair.

This iterative process produces a multipath capacity-limited transit assignment by assuming a hierarchical choice process in which transit lines are considered consecutively in order of their level of service and compared to the highway alternative. The best line is considered first, then the second best, and so on until all demand is exhausted. In this two transit line example, the total transit volume will be $VT12 = CT1 + VT2$ and the total highway volume will be $VC = V - VT12$.

This assignment procedure can be implemented as a simple extension of the customary UTPS procedure. It was applied

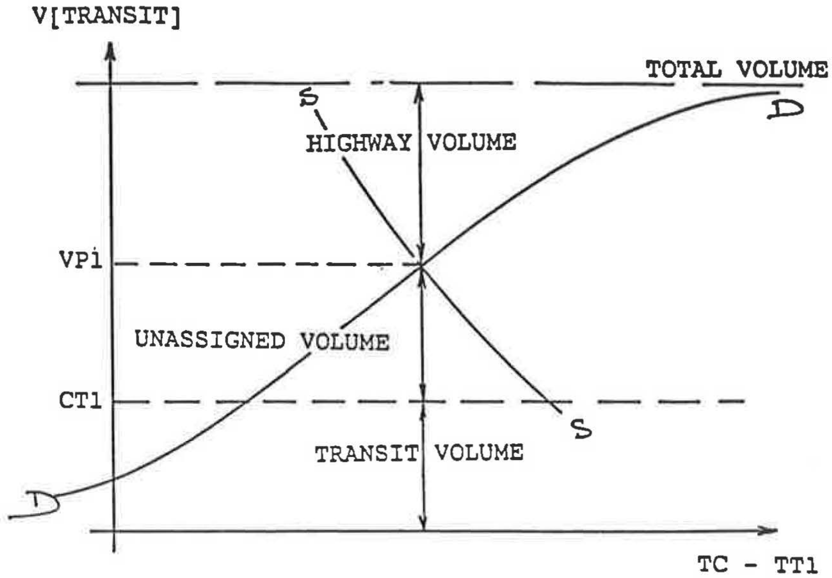

FIGURE 1 Equilibrium between demand and limited-capacity transit line.

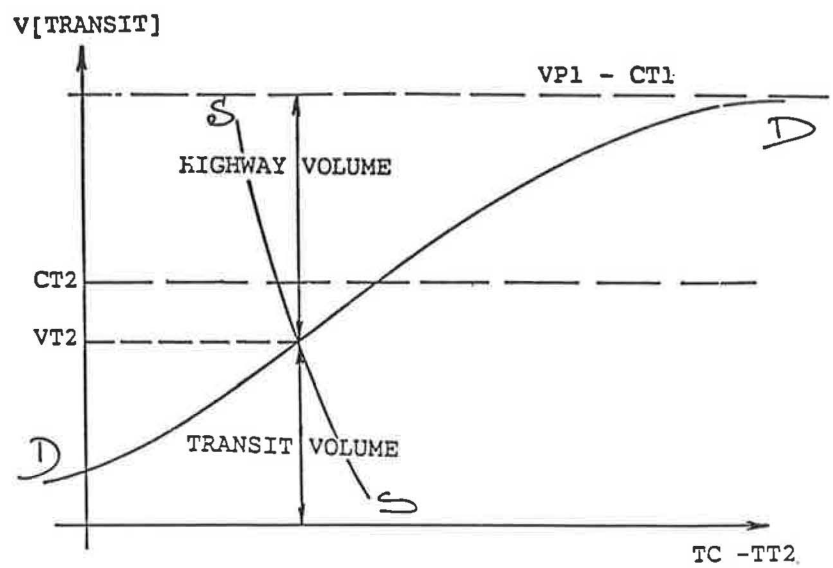

FIGURE 2 Equilibrium between unassigned demand and line 2.

in an almost completely automated way using standard UTPS programs and one additional FORTRAN program. The new proposed method is an iterative procedure, as defined below.

GENERAL DESCRIPTION OF THE PROPOSED ALGORITHM

The proposed algorithm was developed and used for transit alternative investigation in Los Angeles. The need for a capacity-limited assignment arose from the fact that the operating costs of the transit system had to be kept below a predetermined level to meet the agency's budget constraints. The McLAT procedure was used in the final stage of the transit planning process, after an in-depth analysis of various transit alternatives was performed using standard UTPS process. Because of the size of the area and complexity of the transit network, the only practical way to implement the McLAT algorithm was to maximize the use of standard UTPS programs. An iterative procedure was used, consisting of standard UTPS programs such as UPATH, USTOS, UMATRIX, ULOAD(UPRAS), and UMODEL for Logit predictions (*2*), as well as a special FORTRAN program called Overload Line Identification and Network Manipulation (UOLIM) (*3*).

The notation convention for this discussion is as follows:

Notation	*Meaning*
[OD]	original O/D matrix
od	a cell in [OD]
[OD]*xx*	xx% of the original O/D matrix
[OD]*xx*(*i*)	ODxx matrix used in iteration *i*
{*ST*}(*i*)	a set of all stops which a vehicle passes while it carries passengers at or above capacity level at iteration *i*
*NT*0	original (unmodified) transit network

Notation	*Meaning*
$\{LNovl\}(i)$	a set of transit lines which contain stops included in $\{ST\}(i)$
$NT(i)$	modified transit network at iteration i
$[\text{ODovl}](i)$	a matrix containing all O/D pairs whose in-vehicle part of their minimum path starts at a stop included in $\{ST\}(i)$
$[\text{ODfre}](i)$	a matrix containing all O/D pairs whose in-vehicle part of their minimum path *does not* start at a stop included in $\{ST\}(i)$
$[\text{LD}](i)$	Passenger loads on the transit network at iteration i

The proposed algorithm involves the following steps:

1. Take $[\text{OD}]xx$ and $NT0$.
2. Perform a standard UTPS simulation run to produce $[\text{LD}](i)$.
3. Apply UOLIM to identify overloaded stops in $\{ST\}(i)$, to identify overloaded lines $\{\text{LNovl}\}(i)$, and to create a new network $NT(i + 1) = NT0 - \{LNovl\}(i)$.
4. Identify $[\text{ODovl}](i)$ for all stops in $\{ST\}(i)$ using USTOS.
5. Using UMATRIX, create a new yy fraction of $[\text{ODfre}]yy(i + 1)$ and $[\text{ODovl}]yy(i + 1)$, as follows:

$$[\text{OD}]yy(i + 1) = yy*[\text{OD}] \quad (4)$$

$$[\text{ODovl}]yy(i + 1) = [\text{OD}]yy(i + 1) * \begin{Bmatrix} 1 \text{ if od} \ni [\text{ODovl}](i) \\ 0 \text{ otherwise} \end{Bmatrix} \quad (5)$$

$$[\text{ODfre}]yy(i + 1) = [\text{OD}]yy(i + 1) - [\text{ODovl}]yy(i + 1). \quad (6)$$

6. Perform a full UTPS simulation run using network $NT(i + 1)$ and O/D matrix $[\text{ODovl}]yy(i + 1)$ to produce $[\text{LDovl}](i + 1)$.
7. Perform a full UTPS simulation run using network $NT0$ and O/D matrix $[\text{ODfre}]yy(i + 1)$ to produce $[\text{LDfre}](i + 1)$.
8. Using ULOAD(UPRAS), combine transit loads:

$$[\text{LD}](i + 1) = [\text{LD}](i) + [\text{LDfre}](i + 1) + [\text{LDovl}](i + 1). \quad (7)$$

9. Go to Step 3 and repeat through Step 8 with decreasing increments of the OD matrix until all demand is exhausted.

REMARKS ON THE ALGORITHM

The basic idea behind the McLAT algorithm is to assign to transit an increment of the total demand and test the transit lines for overcrowding. In the next step, partition the transit network and another increment of demand into two subsets. One subset includes transit lines that did not reach capacity and all passenger loads belonging to O/D pairs that, in the previous iteration, boarded transit at stops that reached line capacity. Thus those lines are not able to carry additional passengers. Using this set of O/D volumes and subset of the original network, new transit paths in the system are created. The second subset includes the original network and an increment of passenger loads belonging to O/D pairs that boarded the transit system in the previous iteration at stops which had excess capacity. It is these lines that are able to carry additional passenger loads. More details of the algorithm are discussed below.

The algorithm presented above consists mainly of iterations of the customary UTPS process and additional simple manipulation of O/D matrices and transit network coding. The O/D matrix is manipulated using standard UTPS programs, while the network is modified by the UOLIM program. The whole process is automated through a special feature in the UOLIM program, as discussed below. Each iteration except the first consists of applying twice the full sequence of UTPS programs necessary to generate the customary transit assignment. Practical considerations, and the level of overcrowding of the origin network, define the number of iterations and the fraction size of the O/D matrix at each iteration. The fraction size of the O/D matrix used in each successive iteration should be no larger than the one used previously. Furthermore, it makes practical sense to start the iterative process with a relatively high fraction, which can be predetermined by the ratio of unconstrained passenger loads to capacity on the most loaded lines. In most networks, therefore, three to four iterations of the proposed algorithm will produce assignment results that will not overload the transit network by a significant amount.

Most of the algorithm steps are straightforward and do not present any computational problem. All steps except Step 3 are performed using standard UTPS programs. Step 3, however, deserves special explanation regarding the way it operates. This step, which identifies overloaded stops along the transit line, can be implemented in two ways. Assume that at a point in the iterative process zz percent of the total demand was already assigned to the transit network. Then the following two alternatives exist to identify overloaded stops:

1. a stop can be identified as overloaded if passenger loads in the vehicles exceed total capacity of the line; or
2. a stop can be identified as overloaded if passenger loads in the vehicle exceed zz percent of total capacity of the line.

Assume that the first definition is adopted and the overloaded stops occur somewhere downstream along the line. In the next iteration, passengers who board the transit line at stops before the overloaded ones and travel through them will cause loads on the vehicles beyond their stated capacity. This method of simulation might produce unrealistic transit assignment. Trips originating from zones that board the transit line at overloaded stops are overestimated, while trips from zones that board transit at stops where capacity exists are estimated correctly. On the other hand, if the second definition of capacity is adopted, the proposed transit assignment might significantly underestimate passenger loads.

To remedy this problem, Step 3 of the algorithm should be improved. An exact enumeration of all transit paths, while testing for stop's capacity in their order along the transit route, from first to last, cannot be done efficiently given the size of the transit network. A rigorous and efficient mathematical method to solve the problem is not available at present. Given the size of the transit network at hand, the only practical solution was to modify the heuristic approach presented above.

An alternative definition to those presented for testing capacity can be defined as follows. Assume that *zz* percent of total demand was already allocated to the transit network. Let *CAPzz* be a capacity level after *ZZ* percent of total demand was allocated, and let *CAPtot* be the absolute capacity level of the line. Define capacity testing level as:

$$CAPzz = CAPtot*[ZZ + 0.5*(1.0 - ZZ)] \quad (8)$$

This definition for capacity level alleviates most of the problems associated with the two capacity definitions stated above. It will mark a transit stop as overloaded when loads inside the vehicle are above a certain percentage of capacity level. Because this capacity level is still below total capacity, however, additional passengers in the next iteration can board the transit line at upstream stops without violating capacity restrictions. Note that the value of *CAPzz* cannot exceed total capacity of the transit line. This definition represents an intermediate value compared to the two previous capacity definitions.

PROGRAM IMPLEMENTATION AND PROCEDURE AUTOMATION

The main programming effort in the process of implementing the proposed McLAT procedure was in the development of UOLIM program (Overload Line Identification and Network Manipulation). All inputs to this program, except for one, exist as standard UTPS files. There was a need to create an additional file that contains all transit lines and passenger loads at stops along their routes. Although such a file is not created by any of the existing UTPS program, "printed report no. 3" produced by UPRAS module of the ULOAD program (*4*) contains precisely the necessary data. A very simple modification of this program was implemented to create the necessary file optionally. This file contains line identification information and, for each direction and each stop, the number of passengers boarding embarking and travelling in the vehicle. This file is created at Step 8 of the algorithm and is used as input to UOLIM program.

The UOLIM program was coded in FORTRAN following UTPS programming conventions and using its service subroutines. Detailed description of the program is presented in UOLIM user's manual (*3*), and only the main features of the program will be discussed here. The UOLIM program performs mainly the following three tasks:

1. Identify overloaded stops along transit lines;
2. Generate a new transit lines file containing only non-overloaded lines; and
3. Automatically update the JCL stream and control cards for next iteration of the McLAT procedure.

The last two features of the program require further explanation. The generation of the updated transit network is performed as follows. The original lines file is a standard input to the UOLIM program. Each transit line in this file is separately tested for overloading in each direction of travel. If the line is overloaded in both directions, it is completely removed from the network. If it is overloaded in a single direction, only one direction is removed. If the transit line is coded in the correct stops order, only the direction code is changed to indicate a single directional line. If the line is overloaded in the direction opposite to the coded stops, the order of stops is reversed and the directional code is changed to indicate a single directional line. This new lines file is used to perform Step 6 of the algorithm.

The third function of UOLIM program is to automate as much as possible the execution of the proposed McLAT procedure. The program produces very extensive reports of overloaded lines and associated stops, as well as a very extensive statistical summary. However, to run the proposed McLAT procedure many control cards must be prepared after each iteration for USTOS and UMATRIX programs. Manually preparing control cards after each iteration from computer printouts is a lengthy, tedious, and error-prone task. To overcome this problem, UOLIM program accepts as input a JCL file that includes a generic setup of control cards to perform all the USTOS and UMATRIX runs defined in Steps 4 and 5 of the algorithm. The program updates USTOS PARAMETER cards, which are contained in the JCL stream with the list of new overloaded stops. The new updated JCL file can be submitted as is to perform the UTPS runs that execute Steps 4 and 5 of the McLAT procedure. Steps 6 and 7 of the McLAT procedure are standard transit assignment runs and are executed using a standard JCL setup with very little manual intervention. Step 8 of the McLAT procedure is performed by a simple modification of the standard JCL setup for UPRAS module of ULOAD program. Thus the whole McLAT procedure can be run almost automatically without any appreciable additional manual work compared with the manual tasks which are needed to perform a conventional UTPS transit assignment.

The performance of the UOLIM program is extremely flexible. The user can specify capacity levels of transit vehicles by mode and line; transit lines to be excluded from capacity checking by line, mode, or transit company. The choice of capacity check (from the three defined above) can also be specified by the user. Other control parameters of the program dictate various options of network manipulations and the JCL stream updates.

COMPARISON OF TRANSIT ASSIGNMENT RESULTS

To test the performance of the McLAT procedure, it was applied to the Los Angeles metropolitan area in the final analysis stage of one of the proposed alternatives for the Metro Rail system. The alternative chosen for analysis was first evaluated using a standard UTPS procedure, the outline of which is presented in Figure 3. The size of this transportation planning problem is extremely large, consisting of over 1,600 zones, 500 transit lines operated by 12 transit companies, a network of 7,000 nodes and 14,000 links, and four trip purposes (*2*). The motivation for developing and using McLAT was a policy decision by the Southern California Rapid Transit District (SCRTD) to restrict the annual operating costs of its bus system to $525 million.

The operating costs are calculated by the following equation:

$$OPCOST = K0 + K1*[PK\text{-}VEH] + K2*[VHT] + K3*[VMT] + K4*[PSGRS] \quad (9)$$

where

*K*0 through *K*4 = constants,
PK-VEH = the number of peak vehicles necessary to provide the service,
VHT, VMT = the annual hours and maintenance costs of the bus fleet, and
PSGRS = the number of passengers expressed on annual basis.

When the standard UTPS procedure was applied to the network, the demand for transit exceeded the coded bus system capacity. ULOAD and URAP modules (see Figure 3) adjust the line frequencies, up and down, to accommodate demand. The operating costs of the SCRTD bus system, after its service frequencies were adjusted, were about $608 million annually. This exceeded the stated goal of the agency by $83 million annually, or about 15.8 percent. At the same time, the adjusted bus frequencies violated the equilibrium conditions between demand and supply as assumed by the mode choice model.

The McLAT procedure was applied to the same network in the following way:

1. Of the four trip purposes, only HBW trips (home to work and back) were assigned by the McLAT procedure, since most of the overcrowding on the network occurred during the morning and evening peak periods, which are mainly loaded with HBW trips. The other three trip purposes were assigned in one step using the standard UTPS procedure.
2. Three full iterations of the McLAT procedure were performed, assigning successively 40, 30, and 30 percent of total demand.

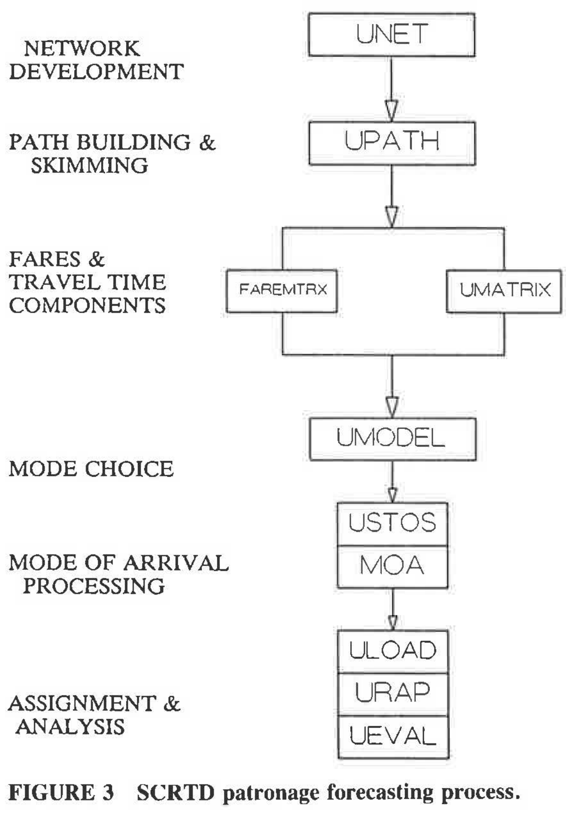

FIGURE 3 SCRTD patronage forecasting process.

Comparison between the results of the standard UTPS procedure and the final outcome of the McLAT procedure are presented in Table 1. The annual operating costs of the McLAT transit assignment are $563 million, saving $45 million relative to the standard UTPS transit assignment. The reduction in operating costs was achieved mainly due to the reduction in peak fleet requirements by 270 buses (there is also a small reduction of 56 vehicles during off-peak periods), thereby reducing the annual fleet hours and maintenance. However, these savings were achieved at the expense of the passenger loads carried: the number of HBW person-trips carried by transit declined by 7.7 percent, from 650,000 to 600,000.

The total reduction of 270 peak buses is the net of eliminating 308 buses operating along 78 transit routes and adding 38 buses operating along 13 transit routes. The number of transit lines along which the number of peak buses increased is a proxy measure for the number of multiple paths created by McLAT procedure, relative to the standard UTPS assignment. In the present simulation this number was not very high: only 13 transit routes, and along 9 of the 13 routes line capacity was reached, indicating that there was not much excess capacity in the alternative transit routes. The relatively small increase in the number of peak buses (38) also points to high crowding on the network.

The number of overloaded transit lines declined from 87 to 76, and the number of overloaded stops from 439 to 320. At first glance this reduction appears to be relative low. However, these figures represent the number of overloaded lines and stops, not the magnitude of overloading. Out of the 76 overloaded bus lines, 31 carried loads in excess of 20 percent of capacity. This figure is much lower, both in the number of overloaded lines as well as load levels, compared to standard UTPS assignment. Fine tuning of the McLAT procedure applying four increments of 40, 30, 20, and 10 percent would have significantly reduced overloading.

Given the complexity of the network and the high level of crowding, it seems that the McLAT procedure performed very well. The stated goal of the agency, to lower operating costs of the bus system to $525 million, was not reached. Analyzing assignment results, it seems that the coded line frequencies and demand patterns were too high. To reach the stated budgetary constraint it would be necessary to further reduce frequencies of the transit service.

CONCLUSIONS

The McLAT procedure presented in this paper served the purpose it was developed for—i.e., to perform transit assignment under capacity restrictions. It is believed based on the experience at hand that McLAT provides more realistic results than the standard UTPS transit assignment. It was developed as a heuristic procedure in the framework of UTPS and can be easily adapted to similar micro and mainframe transportation planning packages. McLAT is an iterative procedure in which almost all manual, error-prone tasks were eliminated. The whole iterative process can be executed in an almost automatic way. Each iteration, however, is a lengthy task. For a network of the size of Los Angeles, under the best circumstances, the turnaround time needed to perform one iteration is one day. Thus to perform the full McLAT

TABLE 1 COMPARISON OF RESULTS OF STANDARD UTPS AND MCLAT PROCEDURE

SYSTEM CHARACTERISTICS	STANDARD UTPS	McLAT PROCEDURE
SCRTD bus lines	287	287
Other bus lines	224	224
Heavy rail	1	1
Light rail	4	4
SCRTD overloaded lines		
Both directions	21	18
One direction	66	58
Overloaded stops	439	320
Daily HBW modal split (persons)		
Auto modes	8,600,000	8,650,000
Transit	650,000	600,000
Transit share (%)	7.0	6.5
Daily non HBW modal split (persons)		
Auto mode	39,000,000	39,000,000
Transit	1,100,000	1,100,000
Transit share (%)	2.7	2.7
SCRTD daily vehicles requirements		
coded pk veh	2,234	2,234
op veh	1,034	1,034
Modified pk veh	2,382	2,112
op veh	1,248	1,192
SCRTD Peak vehicles changes McLAT vs. UTPS		
Reduced pk veh requirements	308	
Increased pk veh requirements	38	
Net savings		270
SCRTD line changes McLAT vs. UTPS		
Reduced pk veh requirements	78	
Increased pk veh requirements	13	
SCRTD annual (1986 $)		
Bus operating costs	608,000,000	563,000,000
Net savings		45,000,000

procedure, while fine tuning it, might require four to five days. This time frame is acceptable only when used as the last stages of the transportation planning process and applied to few prescreened alternatives. At present the McLAT procedure seems a practical and acceptable method to overcome the deficiencies of standard UTPS and similar transit assignment procedures.

However, transit assignment deserves a better fate. From the point of view of software technology and mathematical sophistication, all available transit assignment procedures are at best slight improvements over procedures that are at least 15 years old. We cannot expect to improve the performance and financial integrity of the transit industry if we are unable to provide it with decent planning tools. The McLAT procedure is a very modest step in the right direction. If it does nothing more than stimulate the development of mathematically rigorous multipath capacity-limited assignment, its contribution will be significant.

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