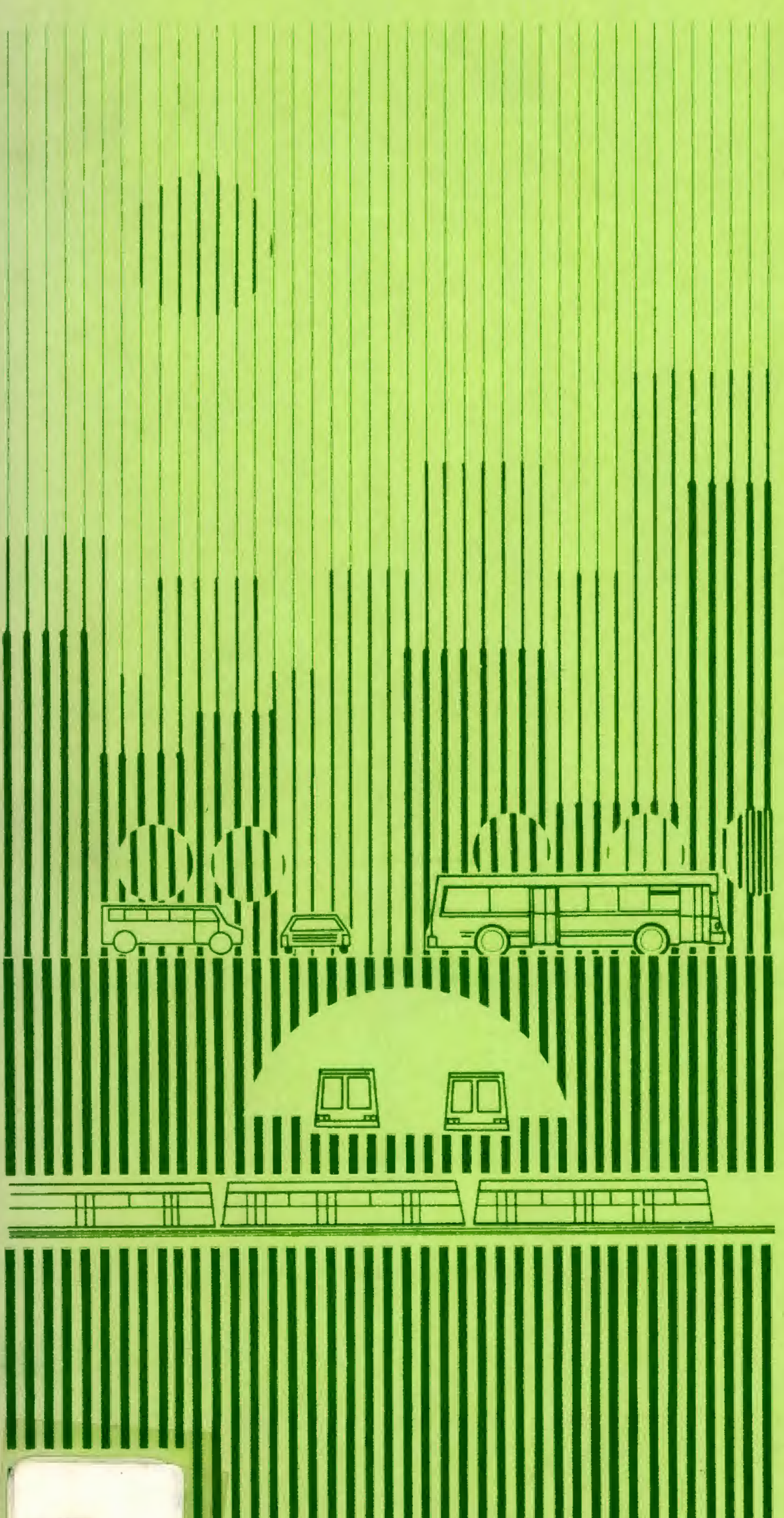

characteristics of urban transportation systems

a handbook for transportation planners

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16. Abstract

*This report consists of a handbook to be used by transportation planners and urban specialists for estimating system parameters for conventional transportation technology. Three modes are evaluated: rail transit, local bus and bus rapid transit, and highway systems. Each mode contains an assessment of the following seven selected supply parameters: speed, capacity, operating cost, energy consumption, pollutant emissions, capital costs, and accident frequency. These parameters are organized as proxy variables in describing the characteristics of each transport mode. Each mode has an analogous Appendix section whereby these parameters are evaluated in further detail and for particular geographic areas. Two additional Appendix sections contain all references used in the tables/figures and a general bibliography for further information.

The report is a part of the Urban Transportation Planning System (UTPS) of UMTA and FHWA and complements the previously distributed UTPS handbooks:

<u>Characteristics of Urban Transportation Demand (CUTD)</u>
Available on the UTPS distribution tape and from NTIS as UMTA-IT-06-0049-78-1
<u>Traveler Response to Transportation System Changes</u>
Limited copies available from FHWA (HHP-22) or from NTIS as PB 265 830/AS

*This report is an update of earlier reports of the same title which have been widely distributed. Limited copies of this report are available from UMTA (UPM-20), from NTIS as PB 233 580/AS, and on the UTPS distribution tape.

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CHARACTERISTICS OF URBAN TRANSPORTATION SYSTEMS

A Handbook For Transportation Planners

THE U.S. DEPARTMENT OF TRANSPORTATION

Urban Mass Transportation Administration

Federal Highway Administration

Office of the Secretary

June 1979

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CUTS COMMENT/UPDATE FORM

THIS MANUAL IS CONTINUOUSLY REVISED TO REFLECT NEW INFORMATION ON TRANSPORTATION SYSTEM CHARACTERISTICS AS IT BECOMES AVAILABLE TO UMTA. TO ASSIST IN THIS REVISION PROCESS, PLEASE SEND ANY COMMENTS YOU MAY HAVE TO THE FOLLOWING ADDRESS, USING THIS FORM:

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DEFINITION OF TERMS

AMORTIZATION PERIOD - THAT TIME PERIOD OVER WHICH A CAPITAL COST ITEM IS FULLY DEPRECIATED.

ARTERIAL STREET - A MAJOR HIGHWAY, PRIMARILY FOR THROUGH TRAFFIC, CHARACTERIZED BY A HIGH CAPACITY AND UNLIMITED ACCESS TO ADJACENT STREETS.

ARTICULATED BUS - A TYPE OF MOTORIZED BUS WHOSE LENGTH (SEAT CAPACITY) IS INCREASED BY THE ADDITION, BY FLEXIBLE JOINT, OF EITHER ANOTHER BUS OR SECTION OF A BUS.

BERTH - A SEPARATE BUS PASSENGER HANDLING PLATFORM CHARACTERIZED BY ITS CONFIGURATION (PARALLEL TO THE PLATFORM OR SAWTOOTH IN DESIGN).

BTU - AN ACRONYM FOR BRITISH THERMAL UNIT: A UNIT OF HEAT EQUAL TO ABOUT 252 CALORIES; THAT QUANTITY OF HEAT REQUIRED TO RAISE THE TEMPERATURE OF ONE POUND OF WATER ONE DEGREE FAHRENHEIT.

BUS PLATOON - SEVERAL BUSES OPERATING TOGETHER AT THE SAME TIME AND OVER THE SAME ROUTE.

BUS RAPID TRANSIT - A BUS OPERATION GENERALLY CHARACTERIZED BY OPERATION ON AN EXCLUSIVE RIGHT-OF-WAY WHERE HIGH SPEEDS CAN BE MAINTAINED.

BUS WAGON (JITNEY) - A TYPE OF BUS DESIGNED TO CARRY 8-12 PERSONS IN LOW PASSENGER DEMAND SITUATIONS; ALSO REFERRED TO AS A VAN.

BUSWAY - A GRADE SEPARATED RIGHT-OF-WAY USED EXCLUSIVELY BY BUSES.

CAPACITY - THE MAXIMUM NUMBER OF VEHICLES OR PASSENGERS WHICH CAN REASONABLY BE EXPECTED TO PASS OVER A FACILITY DURING A GIVEN TIME PERIOD.

CAPITAL COST - THAT MONETARY COST ASSOCIATED WITH INITIATING A PARTICULAR TRANSPORT OPERATION INCLUDING, FOR EXAMPLE, LAND, CONSTRUCTION, AND FLEET, BUT NOT INCLUDING OPERATING COSTS OR MAINTENANCE.

CAR-MILES (BUS-MILES) - THE SUM OF THE DISTANCES (IN MILES) EACH RAIL CAR (BUS) TRAVELS DURING ITS TRANSPORT FUNCTION.

CBD - CENTRAL BUSINESS DISTRICT: THAT CENTRAL PORTION OF A MUNICIPALITY IN WHICH THE DOMINANT LAND USE IS INTENSIVE BUSINESS ACTIVITY.

COMMUTER RAIL - TRANSIT SERVICE OPERATED BY RAILROADS OR TRANSIT AGENCIES CONNECTING NEARBY SUBURBAN AREAS WITH THEIR CENTRAL CITIES AND USING A RIGHT-OF-WAY WHICH MAY ALSO SERVE FREIGHT AND INTERCITY RAIL.

CUT AND COVER - CONSTRUCTION OF AN UNDERGROUND FACILITY BY EXCAVATING AND REFILLING.

DEFAULT VALUE - A DESIGN VALUE BASED UPON SUBSTANTIAL EXPERIENCE OR STUDY CONCLUSIONS TO BE USED FOR ESTIMATING PARAMETERS, GIVEN THE LACK OF MORE DEFINITE INFORMATION.

DWELL TIME - THE PERIOD PRECISELY MEASURED FROM THE TIME A BUS OR TRAIN BERTHS AT A STATION UNTIL THE TIME IT LEAVES.

EXPRESS BUS - A BUS SERVICE USUALLY NOTED BY A SINGLE PASSENGER PICK-UP POINT AND DISCHARGE POINT(S); ALSO NOTED FOR ITS NON-STOP OPERATION BETWEEN ORIGIN AND DISCHARGE POINT(S).

EXPRESSWAY - A DIVIDED HIGHWAY FOR THROUGH TRAFFIC WITH FULL OR PARTIAL ACCESS CONTROL AND GENERALLY WITH GRADE SEPARATIONS AT MAJOR INTERSECTIONS.

FREEWAY - A DIVIDED HIGHWAY FOR THROUGH TRAFFIC WITH FULL ACCESS CONTROL AND GRADE SEPARATION AT ALL INTERSECTIONS.

FRINGE AREA - THAT PORTION OF A MUNICIPALITY IMMEDIATELY OUTSIDE THE CBD WHICH IS CHARACTERIZED BY BUSINESS, INDUSTRIAL, SERVICE, AND SOME RESIDENTIAL ACTIVITY.

INTERRUPTED FLOW - A CONDITION IN WHICH A VEHICLE TRAVERSES A FACILITY AND IS REQUIRED TO STOP OR SLOW DOWN FOR TRAFFIC SIGNALS, FREQUENT INTERSECTIONS, SIGNS, ETC.

LEVEL OF SERVICE - ANY COMBINATION OF OPERATING CONDITIONS OF A GIVEN FACILITY THAT ALLOW IT TO ACCOMMODATE TRAFFIC VOLUMES.

LIGHT RAIL - A TYPE OF TRANSIT SERVICE WITH CARRYING CAPACITY GENERALLY IN BETWEEN THE CAPACITIES OF BUS AND CONVENTIONAL RAPID TRANSIT, CHARACTERIZED BY A STREETCAR-TYPE RAILWAY ON CITY STREETS OR EXCLUSIVE PRIVATE RIGHT-OF-WAY; FORMERLY KNOWN AS "TROLLEY CAR" OR "SUBWAY-SURFACE".

LOCAL BUS - A BUS WHICH PICKS UP PASSENGERS AND DISCHARGES THEM AT FREQUENT, DESIGNATED STOPS.

LOCAL STREET - A STREET OR ROADWAY USED PRIMARILY FOR ACCESS TO ACTIVITIES ON LAND ADJACENT TO IT.

MAJOR WIDENING - ROADWAY CONSTRUCTION TO WIDEN EXISTING ROADWAY TO ACCOMMODATE EXPECTED TRAFFIC.

MEZZANINE AREA - THE PART OF A TRANSIT STATION WHICH IS A PASSENGER COLLECTION AREA SEPARATED FROM THE TRANSPORTATION RIGHT-OF-WAY.

MINIBUS - A CLASS OF BUS WITH LOW PASSENGER CAPACITIES (8-20) AND OPERATING FLEXIBILITY.

NEW ROADS - ROADWAY CONSTRUCTION WHERE NO ROADWAY EXISTS.

NONPROGRESSIVE SIGNAL SYSTEM - A SIGNAL SYSTEM IN WHICH THE SUCCESSIVE SIGNAL FACES CONTROLLING A GIVEN STREET ARE NOT COORDINATED.

OPERATING COST - THOSE RECURRING COSTS IN TRANSPORTATION SYSTEMS WHICH INCLUDE DRIVER WAGES (IF APPLICABLE), SALARIES OF ADMINISTRATIVE OFFICERS, MAINTENANCE, FUEL (POWER), TAXES, INSURANCE, AND SUPPLIES, BUT NOT DEPRECIATION OR INTEREST PAYMENTS.

OPERATING SPEED - THE HIGHEST OVERALL SPEED AT WHICH A VEHICLE CAN BE SAFELY OPERATED UNDER THE TRAFFIC AND ENVIRONMENTAL CONDITIONS WHICH IT ENCOUNTERS.

OBD - OUTLYING BUSINESS DISTRICT: THAT PORTION OF A MUNICIPALITY NORMALLY SEPARATED FROM THE CBD AND FRINGE AREA AND WHERE THE CHIEF LAND USE IS BUSINESS ACTIVITY; CHARACTERIZED BY ITS OWN TRAFFIC CIRCULATION SUPERIMPOSED ON SOME THROUGH TRAFFIC.

PEAK HOUR FACTOR - A RATIO OF THE TRAFFIC VOLUME OCCURRING DURING THE PEAK HOUR TO THE MAXIMUM RATE OF FLOW DURING A SPECIFIED TIME WITHIN THE PEAK HOUR.

PRICE INDEX - AN INDEX OF ANNUAL PRICES FOR A SPECIFIED SET OF YEARS EXPRESSED AS A RATIO TO A SELECTED BASE PRICE.

PROGRESSIVE SIGNAL SYSTEM - A SIGNAL SYSTEM IN WHICH THE SUCCESSIVE SIGNAL FACES CONTROLLING A GIVEN STREET ARE COORDINATED TO GIVE VEHICLES THE OPPORTUNITY TO PASS THROUGH AT A FIXED SPEED WITHOUT STOPPING.

RAIL RAPID TRANSIT - A PASSENGER-CARRYING RAIL SYSTEM ON AN EXCLUSIVE RIGHT-OF-WAY WHICH GENERALLY SERVES ONE CONTIGUOUS URBAN AREA.

RAIL TRANSIT - A GENERIC TERM WHICH INCLUDES RAIL RAPID TRANSIT, LIGHT RAIL AND COMMUTER RAIL SYSTEMS, AND AUXILIARY SERVICES.

RECONSTRUCTION - ROADWAY CONSTRUCTION ON AN EXISTING ROADWAY OR PARTIALLY WHERE NO ROADWAY EXISTS; MAJOR UPGRADING OF A FACILITY.

RESERVED BUS LANE - LANES ON ROADWAYS RESERVED EXCLUSIVELY FOR BUSES AND THEIR OPERATION, ON FREEWAYS, MAJOR ARTERIAL STREETS, OR LOCAL STREETS.

RESIDENTIAL AREA - THAT PORTION OF A MUNICIPALITY IN WHICH THE DOMINANT LAND USE IS RESIDENTIAL. SMALL BUSINESSES MAY ALSO BE INCLUDED.

ROADWAY DESIGN SPEED - A SPEED SELECTED IN ADVANCE SO THAT ALL COMPONENTS OF A SYSTEM CAN BE DESIGNED TO ALLOW SAFE OPERATION AT THAT SPEED.

ROLLING STOCK - ANY VEHICLE CAPABLE OF OPERATING ON THE RIGHT-OF-WAY PROVIDED.

ROUTE (BUS) - A DESIGNATED PATH OVER WHICH A BUS OR FLEET OF BUSES IS ASSIGNED, WITH STOPS FOR SERVING PASSENGERS.

SERVICE VOLUME - THE MAXIMUM NUMBER OF VEHICLES THAT CAN PASS A GIVEN POINT DURING A SPECIFIED TIME PERIOD AT A DESIRED LEVEL OF SERVICE.

SIGNAL PRE-EMPTION - AN ELECTRO-MECHANICAL DEVICE IN A VEHICLE WITH WHICH THE DRIVER CAN ALTER, WITHIN PREDETERMINED BOUNDS, THE SIGNAL CYCLE.

STATIONS - TWO TYPES: OFF-LINE AND ON-LINE. THE FORMER IS A STATION IN WHICH THE VEHICLE STOP IS NOT PART OF THE MAIN LINE. THE LATTER IS A STATION IN WHICH THE VEHICLE STOP IS ON THE MAIN LINE.

TRANSPORTATION COSTS - THAT PART OF OPERATING COSTS WHICH INCLUDES THE COST OF CONDUCTING TRANSPORTATION: DRIVER WAGES, SUPER-VISION, FUEL, AND ASSOCIATED ADMINISTRATIVE COSTS DIRECTLY RELATED TO OPERATION.

UNINTERRUPTED FLOW - A CONDITION IN WHICH A VEHICLE ON A RIGHT-OF-WAY IS NOT REQUIRED TO STOP OR SLOW DOWN DUE TO SIGNALS, SIGNS, OR OPPOSING INTERSECTIONS.

WATT - A UNIT OF POWER WHICH CAN PROVIDE A CURRENT OF ONE AMPERE WITH ONE VOLT; IT IS APPROXIMATELY 1/746 HORSEPOWER.

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CHAPTER I

INTRODUCTION

IN ANY ANALYSIS OF TRANSPORTATION SYSTEMS, WHETHER FOR LONG OR SHORT RANGE PLANNING, THE PLANNER MUST BE ABLE TO ADEQUATELY DESCRIBE A PROPOSED TRANSPORT SYSTEM TO EVALUATE IT PROPERLY. THE LITERATURE OFFERS MANY TOOLS AND METHODOLOGIES FOR PORTRAYING OPERATING, ENVIRONMENTAL, DEMAND, CONSTRUCTION, AND OTHER CHARACTERISTICS OF INDIVIDUAL AND INTEGRATED TRANSPORT TECHNOLOGIES. OFTEN, HOWEVER, THE DATA PRESENTED ARE OUT-OF-DATE, INCONCLUSIVE, CONFUSING, OR MERELY LOCAL IN NATURE. THE VERY NUMBER OF SOURCES CONFUSES RATHER THAN HELPS IN A SEARCH FOR PERTINENT INFORMATION, AND THE GREAT VARIETY OF SOURCES CAN PRODUCE STATISTICS OFTEN UNRELIABLY OR MISLEADINGLY COMPARED OR GROUPED BECAUSE OF MEASUREMENT OR DEFINITIONAL DIFFERENCES.

THE OBJECTIVE OF THIS DOCUMENT IS TO PROVIDE A SINGLE REFERENCE SOURCE FOR THE MOST IMPORTANT (FOR EVALUATION) PERFORMANCE CHARACTERISTICS OF FOUR CONTEMPORARY URBAN TRANSPORTATION SYSTEMS (RAIL, BUS, HIGHWAY-AUTOMOBILE AND MIXED MODE, AND PEDESTRIAN ASSISTANCE SYSTEMS) IN A FORMAT THAT LENDS ITSELF TO EASY REFERENCE. A FIFTH MODE, THE ACTIVITY CENTER SYSTEM, HAS BEEN ADDED: PEOPLE MOVER SYSTEMS INSTALLED AT AIRPORTS, ZOOS, AMUSEMENT PARKS, ETC. THIS HANDBOOK ASSESSES ONLY THE SUPPLY OR PERFORMANCE ASPECT OF URBAN TRANSPORTATION. THIS HANDBOOK DOES NOT DEAL EXPLICITLY WITH PASSENGER DEMAND, BUT ASSESSES ONLY THE SUPPLY OR PERFORMANCE CHARACTERISTICS OF URBAN TRANSPORTATION SYSTEMS. THE SEVEN SUPPLY PARAMETERS CHOSEN FOR THIS REPORT ARE:

- SPEED
  - AVERAGE
  - MAXIMUM
- CAPACITY (SERVICE VOLUME)
  - VEHICLE
  - PERSON
- OPERATING COST (VEHICLE)
- ENERGY CONSUMPTION (VEHICLE OR SOURCE)
- POLLUTION
  - EMISSION (VEHICLE OR SOURCE)
  - NOISE
- CAPITAL COST
  - LAND
  - CONSTRUCTION
  - VEHICLE ACQUISITION
- ACCIDENT FREQUENCY

ORGANIZATION OF HANDBOOK

THE MATERIAL IN THIS HANDBOOK COMES FROM MANY SOURCES, AS THE REFERENCES INDICATE. IT IS A SERIES OF INDEPENDENT, SELF-DESCRIPTIVE TABLES FOR THE FOLLOWING CONVENTIONAL TRANSPORT MODES:

- RAIL TRANSIT (COMMUTER, RAPID, AND LIGHT)

LOCAL BUS AND BUS RAPID TRANSIT
AUTOMOBILE-HIGHWAY SYSTEM (AUTOMOBILES AND OTHER VEHICLES)
ACTIVITY CENTER SYSTEMS
PEDESTRIAN ASSISTANCE SYSTEMS

EACH OF THE ABOVE TRANSPORT MODES IS TREATED IN ITS OWN CHAPTER ACCORDING TO THE SEVEN SUPPLY PARAMETERS. FURTHERMORE, PARAMETERS ARE TYPICALLY DISCUSSED AT SEVERAL LEVELS OF DETAIL TO ASSIST THE URBAN PLANNER IN CHARACTERIZING A PARTICULAR TRANSPORT MODE. THESE LEVELS ARE:

DEFAULT VALUE,
RANGE OF VALUES, AND
THEORETICAL VALUE.

THE DEFAULT VALUE IS A DESIGN VALUE TYPICAL OF THE VALUE, CONDITIONS BEING DESCRIBED. IT IS USUALLY A MEAN OR MEDIAN VALUE AND OFTEN REFLECTS SUBSTANTIAL EMPIRICAL OBSERVATIONS. IT CAN BE USED BY PLANNERS WHERE SITE-SPECIFIC DETAILS ARE NOT AVAILABLE. FOR EXAMPLE, THE AVERAGE OVERALL COMMUTER RAIL SPEED IS 36 MPH (SEE TABLE 2-2).

THE RANGE OF VALUES SHOWS THE HIGH AND LOW VALUES OF A PARAMETER ALLOWING SENSITIVITY ANALYSES TO BE PERFORMED IN THE EVALUATION PHASE. OFTEN IT IS INDICATED WHICH PARTICULAR SYSTEMS EXHIBIT CERTAIN VALUES, AND PLANNERS CAN USE THIS INFORMATION TO CHOOSE MORE ACCURATE VALUES. IN CASES IN WHICH RANGES OF VALUES AND "DEFAULT" SINGLE VALUES ARE PRESENTED, THE USER SHOULD CHECK THE RANGE BEFORE USING A DEFAULT VALUE TO DECIDE IF THE VARIATION DEMANDS MORE SITE-SPECIFIC DETAILS.

AT TIMES, NEITHER THE DEFAULT VALUE NOR THE RANGE OF VALUES IS ADEQUATE, THEN THE THEORETICAL VALUE CAN BE USED. IT IS USUALLY A CONVENIENT MATHEMATICAL FORMULA WHICH THE PLANNER CAN SOLVE TO OBTAIN A THEORETICAL PARAMETER SUCH AS CAPACITY.

SUFFICIENTLY DETAILED QUALIFICATIONS ARE GIVEN WITH EACH TABLE TO MAKE THIS HANDBOOK NEARLY SELF-CONTAINED, YET COMPLETE SOURCE INFORMATION IS GIVEN TO SIMPLIFY THE PROBLEMS OF THE USER WHO REQUIRES FURTHER INFORMATION. EACH SECTION DEALING WITH CONVENTIONAL TRANSPORT HAS ITS OWN APPENDIX WHERE THE MORE IMPORTANT SITE-SPECIFIC INFORMATION IS LISTED. IN ADDITION, TWO OTHER APPENDICES CONTAIN REFERENCES AND A GENERAL BIBLIOGRAPHY. A LIST OF KEY TERMS AND THEIR DEFINITIONS APPEARS AT THE BEGINNING OF THIS HANDBOOK.

USE OF THE HANDBOOK

AS IN THE USE OF OTHER HANDBOOKS OR MANUALS OF THIS TYPE, CARE MUST BE EXERCISED. THIS HANDBOOK IS SPECIFICALLY FOR USE BY TRANSPORTATION PLANNERS IN THE EVALUATION OF ALTERNATIVE SYSTEMS. THE VALUES AND RELATIONSHIPS PRESENTED ARE PURPOSELY SIMPLIFIED. IN MANY CASES, THEREFORE, THEY ARE NOT SUFFICIENTLY REFINED FOR USE IN SUCH STUDIES AS TRANSIT OPERATION ANALYSIS, TRAFFIC ENGINEERING, OR DETAILED DESIGN. THE HANDBOOK CANNOT BE USED WITHOUT COMPREHENSIVE UNDERSTANDING OF THE TRANSPORT SYSTEM BEING ANALYZED. IT IS ESPECIALLY IMPORTANT THAT THE TABLES OR FIGURES USED DESCRIBE THE PARAMETER IN QUESTION ADEQUATELY.

FOR EXAMPLE, IN TABLE 3-11 OR 3-12, THE BUSWAY CONSTRUCTION COSTS ASSUME A CROSS SECTION WIDTH. OTHER NECESSARY PARAMETERS SUCH AS POLLUTION AND ENERGY CONSUMPTION MAY DEPEND ON THE OPERATING CHARACTERISTICS OF THE BUSWAY AS DEFINED BY THE CROSS SECTION ASSUMED. THE PLANNER WHO USES THIS HANDBOOK SHOULD BE AWARE OF THESE ASSUMPTIONS AND CHECK THEM AGAINST HIS KNOWLEDGE OF THE SYSTEM UNDER ANALYSIS.

OBVIOUSLY, VALUES WILL NEED ADJUSTMENT AS TIME PASSES, SINCE THEY ARE STATED IN TERMS OF 1976 PRICES. LOCAL KNOWLEDGE OF WAGE RATES, ENERGY TYPE AND AVAILABILITY, GEOGRAPHY, ARE ONLY SOME FACTORS IMPORTANT TO ACCURATE ANALYSIS. (SOME TRANSPORTATION LABOR AND CONSTRUCTION COST INDICES ARE PRESENTED IN APPENDIX A.)

ALL TABLES ARE UPDATED TO 1976 (UNLESS OTHERWISE INDICATED).

CHAPTER II

RAPID RAIL, COMMUTER RAIL, AND LIGHT RAIL TRANSIT

THIS CHAPTER CONTAINS A SET OF UPDATED (JULY, 1976) QUANTITATIVE VALUES FOR THE SEVEN SUPPLY PARAMETERS SELECTED TO CHARACTERIZE FIXED RAIL TRANSIT SYSTEMS: SPEED, CAPACITY, OPERATING COST, ENERGY CONSUMPTION, POLLUTION (EMISSIONS AND NOISE), CAPITAL COSTS, AND ACCIDENT FREQUENCY. EVERY EFFORT WAS MADE TO PROVIDE DIFFERENT VALUES OR TABLES FOR RAPID RAIL, COMMUTER RAIL, AND LIGHT RAIL TRANSIT SYSTEMS, ALTHOUGH THIS COULD NOT BE COMPLETED FOR ALL THE PARAMETERS. APPENDIX B SHOULD BE CONSULTED FOR CASE OR CITY-SPECIFIC INFORMATION.

IN THIS CHAPTER THERE ARE SEVERAL REFERENCES TO THE INSTITUTE OF RAPID TRANSIT (IRT) AND THE AMERICAN TRANSIT ASSOCIATION (ATA). IN 1974 THESE ORGANIZATIONS MERGED TO FORM THE AMERICAN PUBLIC TRANSIT ASSOCIATION (APTA). REQUESTS FOR SOURCES FROM IRT AND ATA SHOULD BE MADE TO APTA, 1100 17TH STREET, SUITE 1200, WASHINGTON, D.C., 20036.

TABLE 2-1

TYPICAL RAIL RAPID SPEEDS
(1973)

AVERAGE STATION SPACING (MILES)	RANGE OF AVERAGE SPEEDS(1) (MPH)
0-1	20-25
1-2	35-40
2-3	45-50
OVER 3	50-55
DEFAULT VALUE	35-40

(1) THESE SPEEDS REFLECT CURRENT OR EXPECTED RAIL RAPID TECHNOLOGY; THEY INCLUDE ESTIMATES OF TYPICAL DWELL TIMES.

NOTE: SEE TABLE B-2 IN THE APPENDIX AND FIGURE B-1 IN THE CUTS MANUAL FOR EXISTING RAIL RAPID SPEEDS VERSUS STATION SPACING; SEE FIGURE B-2 IN THE CUTS MANUAL FOR CONTEMPORARY RAIL RAPID SPEEDS.

SOURCES: METROPOLITAN ATLANTA RAPID TRANSIT AUTHORITY, UNPUBLISHED DATA, ATLANTA, GEORGIA, 1973

PORT AUTHORITY TRANSIT CORPORATION, UNPUBLISHED DATA, PHILADELPHIA, PENNSYLVANIA, 1973

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY, UNPUBLISHED DATA, WASHINGTON, D.C., 1973

BAY AREA RAPID TRANSIT DISTRICT, UNPUBLISHED DATA, SAN FRANCISCO, CALIFORNIA, 1973

TABLE 2-2

TYPICAL COMMUTER RAIL SPEEDS
(1973)

AVERAGE STATION SPACING (MILES)	RANGE OF AVERAGE SPEEDS(1) (MPH)
0-2	20-30
2-3	28-35
3-5	33-40
5-6	38-45
DEFAULT VALUE	36

(1) THESE SPEEDS REFLECT CURRENT EXISTING COMMUTER RAIL SPEEDS; SPEEDS INCLUDE TYPICAL DWELL TIMES.

NOTE: ABOVE DATA BASED ON ANALYSES OF THE PENN CENTRAL, PENNSYLVANIA-READING SEASHORE LINES, SOUTHERN PACIFIC, CHESSIE SYSTEM, MTA, AND SEVERAL LINES OF THE SOUTHEASTER PENNSYLVANIA TRANSPORTATION AUTHORITY.

SOURCES: PLANNING RESEARCH CORPORATION SYSTEMS SCIENCE COMPANY, "A METHODOLOGY FOR CONDUCTING ECONOMIC AND DEMAND ANALYSES OF NEW SYSTEMS," MARCH, 1973

JOURNAL OF URBAN TRANSPORTATION CORPORATION, MODES OF TRANSPORTATION: SOURCES OF INFORMATION ON URBAN TRANSPORTATION, NEW YORK, AUGUST, 1965

STANFORD RESEARCH INSTITUTE, U.S. PASSENGER TRANSPORTATION: AN INVENTORY OF RESOURCES AND AN ANALYSIS OF CAPABILITIES OF SEVERAL MODES, MENLO PARK, CALIFORNIA, MARCH, 1967

TABLE 2-3

TYPICAL LIGHT RAIL SPEEDS
(1973)

AVERAGE STATION SPACING (MILES)	RANGE OF SPEEDS(1) (MPH)	DEFAULT SPEED(1) (MPH)
0-0.25	9.9-14.3	12.6
0.25-0.50	9.3-18.6	13.5
DEFAULT VALUE		13.0

(1) BASED ON LIGHT RAIL SPEED DATA FROM ROTTERDAM, DUSSELDORF, FRANKFURT (30-40 PERCENT GRADE SEPARATED), STUTTGART (40 PERCENT GRADE SEPARATED), HANOVER, GOTHENBURG (70 PERCENT GRADE SEPARATED), COLOGNE (63 PERCENT GRADE SEPARATED), AND BIELEFELD (40 PERCENT GRADE SEPARATED).

NOTE: LIGHT RAIL DATA FROM U.S. CITIES (BOSTON, NEW ORLEANS, PITTSBURGH, SAN FRANCISCO, PHILADELPHIA, AND CLEVELAND) INDICATE SPEEDS OF 6-11 MPH IN MIXED TRAFFIC AND 10-20 MPH ON PARTIAL GRADE SEPARATION. WITH AN EXCLUSIVE ROW, SEE TABLE 2-4.

SOURCE: VUCHIC, VUKAN, LIGHT RAIL TRANSIT SYSTEMS - A DEFINITION AND EVALUATION, U.S. DEPARTMENT OF TRANSPORTATION, OCTOBER, 1972

TABLE 2-4

RAIL TRANSIT SPEEDS
THEORETICAL CALCULATIONS
(FULLY GRADE SEPARATED)

MAXIMUM SPEED CHIEVED (MPH)	DWELL TIME (SECONDS)	STATION SPACING (MILES) 0.5	1.0	1.5	2.0	2.5	3.0
		AVERAGE SPEED (MPH)(1)					
50	0	34.2	40.6	43.3	44.8	45.8	46.4
	10	28.7	36.5	40.1	42.2	43.5	44.5
	20	24.8	33.1	37.3	39.9	41.5	42.7
	30	21.8	30.3	34.9	37.8	39.7	41.1
60	0	36.0	45.0	49.1	51.4	52.9	54.0
	10	30.0	40.0	45.0	48.0	50.0	51.4
	20	25.7	36.0	41.5	45.0	47.4	49.1
	30	22.5	32.7	38.6	42.4	45.0	47.0
70	0	36.7	48.2	53.7	57.1	59.2	60.8
	10	30.5	42.5	48.9	52.9	55.6	57.5
	20	26.1	38.0	44.8	49.3	52.4	54.7
	30	22.8	34.4	41.4	46.1	49.5	52.0
80	0	36.7	50.2	57.3	61.7	64.7	66.8
	10	30.5	44.1	51.8	56.8	60.3	62.9
	20	26.1	39.3	47.3	52.7	56.5	59.4
	30	22.8	35.4	43.5	49.1	53.2	56.3
90	0	36.7	51.4	60.0	65.5	69.2	72.0
	10	30.5	45.0	54.0	60.0	64.3	67.5
	20	26.1	40.0	49.1	55.4	60.0	63.5
	30	22.8	36.0	45.0	51.4	56.2	60.0

(1) ASSUMES ACCELERATION AND DECELERATION RATES OF 3.0 MPHPS ON TANGENT TRACK ALIGNMENT WITH 0% GRADES.

NOTE: FOR FORMULA SPECIFICATION, SEE TABLE B-3; FOR GRAPHS OF ABOVE DATA, SEE FIGURES B-3 TO B-7 IN THE CUTS MANUAL.

BART, WITH A MAXIMUM ALLOWABLE SPEED OF 80 MPH (AVERAGE RUN OF 47 MPH), HAS AN AVERAGE 10 SECOND STATION DWELL TIME; CHICAGO, WITH A MAXIMUM ALLOWABLE SPEED OF 70 MPH (AVERAGE RUN 30 MPH), HAS AN AVERAGE 20 SECOND DWELL TIME; MBTA (RED LINE), WITH A MAXIMUM ALLOWABLE SPEED OF 70 MPH (AVERAGE RUN 32 MPH), HAS AN AVERAGE 15 SECOND DWELL TIME; NEW YORK SECOND AVENUE, WITH A MAXIMUM ALLOWABLE SPEED OF 70 MPH (AVERAGE RUN OF 28 MPH), HAS AN AVERAGE 30 SECOND DWELL TIME; PATCO, WITH A MAXIMUM ALLOWABLE SPEED OF 75 MPH (AVERAGE RUN 39 MPH), HAS AN AVERAGE 20 SECOND DWELL TIME; AND WASHINGTON, WITH A MAXIMUM ALLOWABLE SPEED OF 80 MPH, HAS NO OBSERVED AVERAGE DWELL TIME.

SOURCE: LANG, A., AND SOBERMAN, R., URBAN RAIL TRANSIT: ITS ECONOMICS AND TECHNOLOGY, MIT PRESS, CAMBRIDGE, MASSACHUSETTS, 1964

TRANSPORTATION SYSTEMS CENTER, SAFETY AND AUTOMATIC TRAIN CONTROL FOR RAIL RAPID TRANSIT SYSTEMS, U.S. DEPARTMENT OF TRANSPORTATION, JULY, 1974

TABLE 2-5

THEORETICAL RAIL TRANSIT SERVICE VOLUME AND SEAT CAPACITY

DWELL TIME (SECONDS)	ACCELERATION (FPS(SQUARED)	LENGTH OF TRAINS (FEET) 150(1)	400(2)	750(3)
		TRAINS PER HOUR(SEATED PERSONS PER HOUR)		
10	2	96(13440)	72(30240)	61(42700)
	3	105(14700)	80(33600)	69(48300)
	4	111(15540)	87(36540)	75(52500)
20	2	76(10640)	60(25200)	52(36400)
	3	81(11340)	66(27720)	58(40600)
	4	85(11900)	70(29400)	62(43400)
30	2	62(8680)	51(21420)	45(31500)
	3	66(9240)	55(23100)	50(35000)
	4	68(9520)	58(24360)	53(37100)
40	2	53(7420)	45(18900)	40(28000)
	3	56(7840)	48(20160)	44(30800)
	4	57(7980)	50(21000)	46(32200)
50	2	46(6440)	40(16800)	36(25200)
	3	48(6720)	42(17640)	39(27300)
	4	49(6860)	44(18480)	41(28700)

DEFAULT VALUE - - - - - 40 TRAINS PER HOUR

(1) ASSUMES TWO CARS PER TRAIN (150 FEET) WITH 70 SEATS PER CAR.
(2) ASSUMES SIX CARS PER TRAIN (450 FEET) WITH 70 SEATS PER CAR.
(3) ASSUMES TEN CARS PER TRAIN (750 FEET) WITH 70 SEATS PER CAR.

NOTES: DATA INCLUDE ON-LINE STOPS. FOR APPROXIMATELY COMPARABLE BUS FIGURES, SEE TABLE 3-4 FOR BUSES OPERATING IN PLATOONS WITH ON-LINE STOPS. NOTE THAT FOR RAIL, LINE VOLUME CONTROLS, WHILE FOR BUS, BOARDING VOLUME CONTROLS.

SEE TABLE 2-4 FOR EXAMPLES OF PRESENT TRANSIT DWELL TIMES.

FOR FORMULA SPECIFICATION, SEE TABLE B-4.

NUMBERS IN PARENTHESES ARE ASSUMED SEATED PASSENGERS CARRIED PER HOUR; IF STANDEES ARE INCLUDED, VALUES CAN BE INCREASED BY 3-4 TIMES (SEE TABLES B-5 AND B-6).

TABLE 3-4 (FOR BUSES) IS ANALOGOUS TO THE ABOVE TABLE.

THIS TABLE CAN BE USED TO ESTIMATE LIGHT RAIL SERVICE VOLUMES BY USING 10-30 SECOND DWELL TIMES, 3-4 FPS SQUARED ACCELERATION, AND 150 FOOT TRAIN LENGTHS OR APPLYING FORMULA (TABLE B-4) FOR PARTICULAR VALUES.

SOURCE: LANG, A., AND SOBERMAN, R., URBAN RAIL TRANSIT: ITS ECONOMICS AND TECHNOLOGY, MIT PRESS, CAMBRIDGE, MASSACHUSETTS, 1964

TABLE 2-6

RAIL RAPID TRANSIT OPERATING COSTS

VALUE(1,2)	MAINTENANCE OF WAYS AND STRUCTURES	MAINTENANCE OF VEHICLES	POWER	TRANSPORTATION	GENERAL AND ADMINISTRATIVE	TOTAL
			(PER CAR-MILE)			
DEFAULT	$0.37	$0.31	$0.32	$1.00	$0.40	$2.40
RANGE	$0.19-$0.92	$0.26-$0.59	$0.14-$0.40	$1.53-$1.30	$0.33-$1.93	$1.88-$3.90

(1) BASED ON DATA COLLECTED FROM FIVE U.S. RAIL RAPID TRANSIT SYSTEMS FOR 1975 AND ADJUSTED TO REFLECT 1976 PRICES; THE SYSTEMS INCLUDED: PATH, MTA, CTA, SEPTA, AND PATCO.

(2) MAINTENANCE OF WAYS AND STRUCTURES INCLUDES COSTS OF CONSTRUCTION, MAINTENANCE, INJURIES, ETC., ASSOCIATED WITH THIS PART OF THE OPERATION. MAINTENANCE OF VEHICLES INCLUDES COSTS OF ROLLING STOCK AND LABOR. POWER INCLUDES COSTS OF YARD AND LINE POWER REQUIRED. TRANSPORTATION INCLUDES COSTS IN LABOR ASSOCIATED WITH DISPATCHING, PROVIDING OPERATORS, AND MATERIAL FOR PROVIDING TRAINS. GENERAL AND ADMINISTRATIVE INCLUDES COSTS FOR ADVERTISING, EMPLOYEE BENEFITS, ADMINISTRATIVE, ETC. DEPRECIATION AND INTEREST ARE NOT INCLUDED. FOR EXACT DEFINITION CONSULT APTA TRANSIT OPERATING REPORT.

SOURCES: AMERICAN PUBLIC TRANSIT ASSOCIATION, TRANSIT OPERATING REPORT, 1976, WASHINGTON,D.C.

WELLS, J., ASHER, N., FLOWERS, M., ET AL, ECONOMIC CHARACTERISTICS OF THE URBAN PUBLIC TRANSPORTATION INDUSTRY, INSTITUTE FOR DEFENSE ANALYSES, FEBRUARY, 1972

INSTITUTE FOR RAPID TRANSIT (NOW APTA), TRANSIT CAR DATA BOOK III, WASHINGTON, D.C., 1971

BHATT, K., AND OLSSON, M., "ANALYSIS OF SUPPLY AND ESTIMATES OF RESOURCE COSTS," TECHNICAL REPORT 2, THE URBAN INSTITUTE, WASHINGTON, D.C., NOVEMBER, 1973

TABLE 2-7

COMMUTER RAIL OPERATING COSTS

VALUE (1,2)	MAINTENANCE OF ROADWAYS AND STRUCTURES	MAINTENANCE OF EQUIPMENT	TRANSPORTATION	TRAFFIC	OTHER	TOTAL
	(PER CAR-MILE)					
DEFAULT	$0.44	$0.88	$3.10	$0.04	$0.23	$4.69
RANGE	$0.22-$0.95	$0.51-$1.29	$2.02-$4.32	$0.01-$0.07	$0.13-$0.22	$3.09-$6.45

(1) BASED ON DATA COLLECTED FROM 10 U.S. COMMUTER RAIL SYSTEMS FOR THE PERIOD 1972 AND ADJUSTED TO REFLECT 1976 PRICES.

(2) MAINTENANCE ON ROADWAY AND STRUCTURES INCLUDES CONSTRUCTION, MAINTENANCE, INJURIES, AND RIGHTS-OF-WAY. MAINTENANCE OF EQUIPMENT INCLUDES ROLLING STOCK, MACHINERY, AND INJURIES. TRANSPORTATION INCLUDES LABOR, YARD SUPPLIES, POWER, INJURIES, AND OTHER ITEMS RELATED TO SUPPLYING TRANSPORT. TRAFFIC INCLUDES ADVERTISING, HEALTH AND WELFARE, ETC. OTHER INCLUDES TRAVEL, LEGAL, OFFICE SUPPLIES, AND LABOR IN ADMINISTRATIVE OFFICES.

NOTE: THE ABOVE OPERATING COST TABLE FOLLOWS THE FORMAT OF THE UNIFORM SYSTEM OF ACCOUNTS FOR RAILROAD COMPANIES AS REGULATED BY THE INTERSTATE COMMERCE ACT, 1961.

SEE TABLE B-8 FOR OPERATING COST INVENTORY OF 10 COMMUTER RAIL SYSTEMS.

SOURCE: INTERSTATE COMMERCE COMMISSION, "ANNUAL OPERATING REPORTS," WASHINGTON, D.C., 1972

TABLE 2-8

LIGHT RAIL TRANSIT OPERATING COSTS

VALUE (1,2)	MAINTENANCE OF WAYS AND STRUCTURES	MAINTENANCE OF VEHICLES	POWER	TRANSPORTATION	GENERAL AND ADMINISTRATIVE	TOTAL
			(PER CAR-MILE)			
DEFAULT	$0.51	$0.42	$0.30	$0.97	$0.62	$2.82
RANGE	$0.23-$0.70	$0.20-$0.56	$0.10-$0.43	$0.78-$1.17	$0.48-$0.89	$2.19-$3.08

(1) BASED ON DATA COLLECTED FROM FOUR U.S. LIGHT RAIL TRANSIT SYSTEMS FOR 1975 AND ADJUSTED TO REFLECT 1976 PRICES; SYSTEMS INCLUDE NEWARK, NEW ORLEANS, PHILADELPHIA, AND SHAKER HEIGHTS.

(2) MAINTENANCE OF WAYS AND STRUCTURES INCLUDES COSTS OF CONSTRUCTION, MAINTENANCE, INJURIES, ETC., ASSOCIATED WITH THIS PART OF THE OPERATION; MAINTENANCE OF VEHICLES INCLUDES COSTS OF ROLLING STOCK AND LABOR; POWER INCLUDES COST OF YARD AND LINE POWER REQUIRED; TRANSPORTATION INCLUDES COSTS IN LABOR ASSOCIATED WITH DISPATCHING, PROVIDING OPERATORS AND MATERIAL FOR PROVIDING TRAINS; AND GENERAL AND ADMINISTRATIVE INCLUDES COSTS FOR ADVERTISING, EMPLOYEE BENEFITS, ADMINISTRATIVE, ETC. OPERATING COSTS DO NOT INCLUDE DEPRECIATION OR INTEREST PAYMENTS. FOR EXACT DEFINITION, CONSULT APTA _TRANSIT OPERATING REPORTS_.

SOURCE: SEE TABLE B-9

TABLE 2-9

ELECTRIC RAIL RAPID TRANSIT ENERGY CONSUMPTION

	DEFAULT VALUE	RANGE OF VALUES
ELECTRICAL(1) ENERGY SOURCE	ENERGY CONSUMPTION (PER CAR-MILE)	ENERGY CONSUMPTION(2) (PER CAR-MILE)
COAL	4.10 POUNDS	3.65-8.20 POUNDS
NO. 6 FUEL OIL	0.35 GALLONS	0.33-0.37 GALLONS
DIESEL FUEL	0.37 GALLONS	0.35-0.39 GALLONS
GASOLINE	0.41 GALLONS	0.39-0.44 GALLONS
FURNACE OIL	0.38 GALLONS	0.36-0.40 GALLONS
KEROSENE	0.40 GALLONS	0.37-0.44 GALLONS
NATURAL GAS	48.00 CUBIC FEET	42.00-53.00 CUBIC FEET
MANUFACTURED GAS	96.00 CUBIC FEET	80.00-132.00 CUBIC FEET

(1) AVERAGE CONSUMPTION FOR RAIL TRANSIT SYSTEMS IS ABOUT 5.3 KILOWATT-HOURS PER CAR-MILE.

(2) BASED ON 1960 DATA FROM THE FOLLOWING RAIL TRANSIT SYSTEMS: CLEVELAND, TORONTO, PHILADELPHIA, CHICAGO, AND NEW YORK.

SOURCES: FINK, D.G., AND CARROLL, J.M., STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS, MCGRAW-HILL, NEW YORK, 1963

WELLS, J.D., ASHER, N.J., FLOWERS, M.R., ET AL, ECONOMIC CHARACTERISTICS OF THE URBAN PUBLIC TRANSPORTATION INDUSTRY, INSTITUTE FOR DEFENSE ANALYSES, WASHINGTON, D.C., FEBRUARY, 1972

LANG, A.S., AND SOBERMAN, R.M., URBAN RAIL TRANSIT: ITS ECONOMICS AND TECHNOLOGY, MIT PRESS, CAMBRIDGE, MASSACHUSETTS, 1964

TABLE 2-10

DIESEL COMMUTER RAIL TRANSIT ENERGY CONSUMPTION

VALUE	DIESEL CONSUMPTION (PER CAR-MILE)
DEFAULT	1.9 GALLONS
RANGE	1.4-2.4 GALLONS

SOURCE: DELEUW, CATHER AND COMPANY, ENERGY ANALYSIS OF URBAN PASSENGER TRAVEL ALTERNATIVES, WASHINGTON, D.C., APRIL, 1974

TABLE 2-11

ELECTRIC LIGHT RAIL TRANSIT ENERGY CONSUMPTION

ELECTRICAL ENERGY SOURCE(1)	DEFAULT VALUE ENERGY CONSUMPTION (PER CAR MILE)	RANGE OF VALUES ENERGY CONSUMPTION (PER CAR-MILE)
COAL	3.18 POUNDS	2.83-6.36 POUNDS
NO. 6 FUEL OIL	0.27 GALLONS	0.26-0.29 GALLONS
DIESEL FUEL	0.29 GALLONS	0.27-0.30 GALLONS
GASOLINE	0.32 GALLONS	0.30-0.34 GALLONS
FURNACE OIL	0.29 GALLONS	0.28-0.31 GALLONS
KEROSENE	0.31 GALLONS	0.29-0.34 GALLONS
NATURAL GAS	37.20 CUBIC FEET	32.55-41.08 CUBIC FEET
MANUFACTURED GAS	74.40 CUBIC FEET	62.00-102.30 CUBIC FEET

(1) AVERAGE CONSUMPTION FOR LIGHT RAIL TRANSIT SYSTEMS IS ABOUT 4.1 KILOWATT-HOURS PER CAR-MILE. DEFAULT VALUE AND RANGE OF VALUES BASED ON THIS EFFICIENCY FACTOR APPLIED TO TABLE 2-9.

NOTE: NEWARK USES 4.68; PITTSBURGH, 7.89; NEW ORLEANS, 4.10; SHAKER HEIGHTS, 4.26 KILOWATT-HOURS PER MILE.

SOURCES: FINK, D.G., AND CARROLL, J.M., STANDARD HANDBOOK FOR ELECTRICAL ENGINEERS, MCGRAW-HILL, NEW YORK, 1963

WELLS, J.D., ASHER, N.J., FLOWERS, M.R., ET AL, ECONOMIC CHARACTERISTICS OF THE URBAN PUBLIC TRANSPORTATION INDUSTRY, INSTITUTE FOR DEFENSE ANALYSES, WASHINGTON, D.C., FEBRUARY, 1972

LANG, A.S., AND SOBERMAN, R.M., URBAN RAIL TRANSIT: ITS ECONOMICS AND TECHNOLOGY, MIT PRESS, CAMBRIDGE, MASSACHUSETTS, 1964

AMERICAN TRANSIT ASSOCIATION (NOW APTA), TRANSIT OPERATING REPORT, WASHINGTON, D.C., 1973

TABLE 2-12

MAGNITUDE OF POLLUTANTS GENERATED BY RAIL RAPID TRANSIT
POWERED BY ELECTRICAL ENERGY(1)

	ELECTRICAL ENERGY SOURCE		
POLLUTANT	COAL (GRAMS/) (CAR-MILE)	NATURAL GAS (GRAMS/) (CAR-MILE)	RESIDUAL(2) OIL (GRAMS/) (CAR-MILE)
CARBON MONOXIDE (CO)	0.4536	NEGL.	0.0068
HYDROCARBONS (HC)	0.1860	NEGL.	0.5443
OXIDES OF NITROGEN (NOX)	18.5976	9.5256	17.6904
OXIDES OF SULFUR (SOX)	69.8544	0.0095	13.6080
ALDEHYDES	0.0045	0.0240	0.1043
PARTICULATES	146.5128	0.3629	1.7237
TOTALS	235.6089	9.9220	33.6775

(1) ASSUMES 5.3 KWHR/CAR-MILE, .5% SULFUR CONTENT FOR OIL, AND 10% ASH CONTENT FOR COAL.
(2) RESIDUAL OIL INCLUDES FUEL OIL AND FURNACE OIL.

NOTE: THE TYPE, AGE, CONTROL DEVICES, AND LOCATION OF THE POWER GENERATING PLANT CAN MAKE A LARGE DIFFERENCE IN THE QUANTITIES OF POLLUTANTS EMITTED. THESE RATES ASSUME NO STACK (SCRUBBER) CONTROLS FOR THE GENERATING PLANT. IF STACK CONTROLS WERE PLACED ON THE PLANT TO REDUCE SOX AND PARTICULATES BY A CERTAIN PERCENTAGE, THE RATES FOR SOX AND PARTICULATES SHOULD BE REDUCED BY THAT PERCENTAGE - E.G., A 50 PERCENT CAPTURE OF SOX AND PARTICULATES WOULD REDUCE THE SOX AND PARTICULATE EMISSION RATES 50 PERCENT. STACK CONTROLS WOULD CAUSE A NEGLIGIBLE REDUCTION IN THE NOX RATES AND NO REDUCTION IN THE CO, HC, AND ALDEHYDE POLLUTION RATES.

SOURCE: WELLS, J.D., ASHER, N.J., FLOWERS, M.R., ET AL, <u>ECONOMIC CHARACTERISTICS OF THE URBAN PUBLIC TRANSPORTATION INDUSTRY</u>, INSTITUTE FOR DEFENSE ANALYSES, WASHINGTON, D.C. FEBRUARY, 1972

TABLE 2-13

MAGNITUDE OF POLLUTANTS GENERATED BY LIGHT RAIL TRANSIT
POWERED BY ELECTRICAL ENERGY (1)

	ELECTRICAL ENERGY		
POLLUTANT(3)	COAL (GRAMS/) (CAR-MILE)	NATURAL GAS (GRAMS/) (CAR-MILE)	RESIDUAL(2) OIL (GRAMS/) (CAR-MILE)
CARBON MONOXIDE (CO)	0.3515	NEGL.	0.0053
HYDROCARBONS (HC)	0.1442	NEGL.	0.4218
OXIDES OF NITROGEN (NOX)	14.4131	7.3823	13.7101
OXIDES OF SULFUR (SOX)	54.0383	0.0074	10.5462
ALDEHYDES	0.0035	0.0186	0.0808
PARTICULATES	113.3401	0.2812	1.3359
TOTALS	182.2907	7.6895	26.1001

(1) ASSUMES SINGLE CAR OPERATION, 4.1 KWHR/CAR-MILE, 0.5% SULFUR CONTENT FOR OIL, AND 10% ASH CONTENT FOR COAL.
(2) RESIDUAL OIL INCLUDES FUEL OIL AND FURNACE OIL.
(3) DEFAULT VALUE AND RANGE OF VALUES ARE BASED ON THIS EFFICIENCY FACTOR APPLIED TO TABLE 2-11.

NOTE: THE TYPE, AGE, CONTROL DEVICES, AND LOCATION OF THE POWER GENERATING PLANT CAN MAKE A LARGE DIFFERENCE IN THE QUANTITIES OF POLLUTANTS EMITTED. THESE RATES ASSUME NO STACK (SCRUBBER) CONTROLS FOR THE GENERATING PLANT. IF STACK CONTROLS WERE PLACED ON THE PLANT TO REDUCE SOX AND PARTICULATES BY A CERTAIN PERCENTAGE, THE RATES FOR SOX AND PARTICULATES SHOULD BE REDUCED BY THAT PERCENTAGE - E.G., A 50 PERCENT CAPTURE OF SOX AND PARTICULATES WOULD REDUCE THE SOX AND PARTICULATE EMISSION RATES 50 PERCENT. STACK CONTROLS WOULD CAUSE A NEGLIGIBLE REDUCTION IN THE NOX RATES AND NO REDUCTION IN THE CO, HC, AND ALDEHYDE POLLUTION RATES.

TABLE 2-14

MAGNITUDE OF POLLUTANTS GENERATED BY COMMUTER RAIL DIESEL LOCOMOTIVE (1970)

POLLUTANT	MAGNITUDE (GRAMS/MILE)
CARBON MONOXIDE (CO)	30.8
HYDROCARBONS (HC)	22.0
OXIDES OF NITROGEN (NOX)	33.0
OXIDES OF SULFUR (SOX)	28.6
ALDEHYDES	1.8
PARTICULATES	11.0
ORGANIC ACIDS	3.1

NOTE: DATA ARE BASED ON WEIGHTING FACTORS APPLIED TO ACTUAL TESTS CONDUCTED AT VARIOUS LOAD AND IDLE CONDITIONS WITH AN AVERAGE GROSS VEHICLE WEIGHT OF 30 TONS AND FUEL CONSUMPTION OF ABOUT 5.0 MILES PER GALLON.

DATA ARE BASED ON AN AVERAGE SULFUR CONTENT OF 0.50 PERCENT.

SOURCE: UNPUBLISHED TEST DATA ON LOCOMOTIVE ENGINES. GENERAL MOTORS CORPORATION, WARREN, MICHIGAN, JULY, 1970.

TABLE 2-15

NATIONAL DISTRIBUTION OF FUEL SOURCES FOR ELECTRIC POWER GENERATION (1) (1950-1975)

FUEL SOURCE	1950	1955	1960	1965	1970	1975
COAL	47.1	55.1	53.6	54.5	45.2	44.7
HYDRO	29.2	20.7	19.3	18.4	16.9	15.8
NATURAL GAS	13.5	17.4	21.0	21.0	24.6	15.7
RESIDUAL OIL(2)	10.3	6.8	6.1	6.1	12.0	15.1
NUCLEAR	--	--	--	--	1.5	8.9

(1) FOSSIL FUEL PROVIDES OVER 80 PERCENT OF POWER NEEDED FOR RAIL TRANSIT SYSTEMS. EACH LOCATION, HOWEVER, SHOWS ITS OWN CHARACTERISTICS, AND THUS THERE IS A LARGE VARIANCE IN THIS FIGURE. IN CHICAGO, FOR EXAMPLE, IN 1971, COAL SUPPLIED 54-59 PERCENT OF POWER, NUCLEAR 30-35 PERCENT, OIL 7 PERCENT, AND NATURAL GAS 4 PERCENT FOR TRANSIT SYSTEMS.

(2) RESIDUAL OIL INCLUDES FUEL OIL AND FURNACE OIL.

SOURCE: U. S. STATISTICAL ABSTRACT, 1976

TABLE 2-16

NATIONAL COMPOSITE OF POLLUTANTS GENERATED BY FUEL SOURCES FOR RAIL RAPID TRANSIT (1) (1972)

	FUEL			
POLLUTANT	COAL (GRAMS/) (CAR-MILE)	NATURAL GAS (GRAMS/) (CAR-MILE)	RESIDUAL OIL(2) (GRAMS/) (CAR-MILE)	AVERAGE POLLUTANTS GENERATED (GRAMS/) (CAR-MILE)
CARBON MONOXIDE (CO)	0.2000	0.0000	0.0011	0.2011
HYDROCARBONS (HC)	0.0820	0.0000	0.0849	0.1669
OXIDES OF NITROGEN (NOX)	8.2015	2.0480	2.7597	13.0092
OXIDES OF SULFUR (SOX)	30.8057	0.0020	2.1228	32.9305
ALDEHYDES	0.0020	0.0052	0.0163	0.0235
PARTICULATES	64.6121	0.0780	0.2689	64.9590

(1) THIS TABLE WAS CALCULATED BY MULTIPLYING THE NUMBER OF GRAMS OF POLLUTANTS PER CAR-MILE FOR EACH ENERGY SOURCE (1972) GIVEN IN TABLE 2-12 BY THE PERCENT OF ELECTRICITY GENERATED BY THAT ENERGY SOURCE AS GIVEN IN TABLE 2-15. IT WAS ASSUMED THAT NO POLLUTANT EMISSIONS RESULTED FROM GENERATING ELECTRICITY BY WATER, AND NUCLEAR ENERGY AIR POLLUTION WAS MINIMAL.

(2) RESIDUAL OIL INCLUDES FUEL OIL AND FURNACE OIL.

SAMPLE CALCULATION

AVERAGE CO/CAR-MILE=(.4410)(.4536)+(.2150)(NEGL.)+(.1560)(.0068)= 0.2011 GRAMS/CAR-MILE

TABLE 2-17

NATIONAL COMPOSITE OF POLLUTANTS GENERATED BY FUEL SOURCES FOR LIGHT RAIL TRANSIT (1) (1972)

POLLUTANT	FUEL: COAL (GRAMS/ CAR-MILE)	FUEL: NATURAL GAS (GRAMS/ CAR-MILE)	FUEL: RESIDUAL OIL(2) (GRAMS/ CAR-MILE)	AVERAGE POLLUTANTS GENERATED (GRAMS/ CAR-MILE)
CARBON MONOXIDE (CO)	0.1550	0.0000	0.0008	0.1558
HYDROCARBONS (HC)	0.0636	0.0000	0.0658	0.1294
OXIDES OF NITROGEN (NOX)	6.3562	1.5872	2.1388	10.0822
OXIDES OF SULFUR (SOX)	23.8379	0.0016	1.6452	25.4779
ALDEHYDES	0.0015	0.0040	0.0126	0.0181
PARTICULATES	49.9830	0.0605	0.2084	50.2519

(1) THIS TABLE WAS CALCULATED BY MULTIPLYING THE NUMBER OF GRAMS OF POLLUTANTS PER CAR-MILE FOR EACH ENERGY SOURCE (1972) GIVEN IN TABLE 2-13 THE PERCENT OF ELECTRICITY GENERATED BY THAT ENERGY SOURCE AS GIVEN IN TABLE 2-15. IT WAS ASSUMED THAT NO POLLUTANT EMISSIONS RESULTED FROM GENERATING ELECTRICITY BY WATER, AND NUCLEAR ENERGY AIR POLLUTION WAS MINIMAL.

(2) RESIDUAL OIL INCLUDES FUEL OIL AND FURNACE OIL.

<u>SAMPLE CALCULATION</u>

AVERAGE CO/CAR-MILE=(.4410)(.3515)+(.2150)(NEGL.)+(.1560)(.0053) = 0.1558 GRAMS/CAR-MILE

TABLE 2-18

RAPID RAIL NOISE EXPOSURE

FACILITY	IN SUBWAY (DBA) (1)	AT STATION (DBA) (2)	AT GRADE INSIDE VEHICLE (DBA) (3)	AT GRADE OUTSIDE VEHICLE (DBA) (4)
MBTA	97	--	--	--
CTS	89-98	82-106	--	--
NYTA	90-98	78-108	83	--
TORONTO	84-90	84-96	--	79
PARIS(RUBBER TIRE)	81-89	68-101	--	--
PARIS(STEEL WHEEL)	99	81-108	--	--
SOAC	--	--	61-72	72-82
METRO(WASHINGTON)(5)	75-77	--	--	--

(1) MEASUREMENTS TAKEN INSIDE VEHICLE.
(2) MEASUREMENTS TAKEN AT STATION OUTSIDE VEHICLE FOR TRAINS PASSING THROUGH AND STOPPING/STARTING.
(3) MEASUREMENTS TAKEN ON AT-GRADE, TANGENT SECTION, WELDED RAIL, INSIDE VEHICLE.
(4) MEASUREMENTS TAKEN ON AT-GRADE, TANGENT SECTION, WELDED RAIL 50 FEET FROM VEHICLE.
(5) NOISE SPECIFICATIONS.

NOTE: NOISE READINGS DEPEND ON MANY FACTORS INCLUDING SPEED, TRAIN LENGTH, TYPE OF TRACK, OVERHEAD STRUCTURES; NOISE DECAYS AS A FUNCTION OF DISTANCE.

EXISTING LIGHT RAIL SYSTEMS TYPICALLY GENERATE NOISE LEVELS BETWEEN 68-80 DBA AT THE SURFACE AND 50 FEET FROM THE VEHICLE; EXISTING COMMUTER RAIL SYSTEMS TYPICALLY GENERATE NOISE LEVELS BETWEEN 70-75 DBA INSIDE VEHICLE AT HIGH SPEEDS AND 80-90 DBA AT THE SURFACE AND 50 FEET FROM THE VEHICLE.

SOURCES: OPERATIONS RESEARCH INCORPORATED, COMPARISON OF NOISE AND VIBRATION LEVELS IN RAPID TRANSIT VEHICLE SYSTEMS, NCTA TECHNICAL REPORT, APRIL, 1964

BOEING VERTOL COMPANY, SOAC - STATE-OF-THE-ART CAR DEVELOPMENT PROGRAM, PHILADELPHIA, PENNSYLVANIA, APRIL, 1974

WYLE LABORATORIES, TRANSPORTATION NOISE AND NOISE FROM EQUIPMENT POWERED BY INTERNAL COMBUSTION ENGINES, WASHINGTON, D.C., DECEMBER, 1971

TABLE 2-19

RAPID AND LIGHT RAIL TRANSIT LAND COSTS
($MILLION PER MILE)

LOCATION(1)	POPULATION GROUPS (1000'S) UNDER 50	50-100	100-250	250-500	500-1000	OVER 1000
CBD	1.05	1.05	1.26	1.58	2.10	3.24
FRINGE	1.05	1.05	1.14	1.26	1.58	2.10
RESIDENTIAL	0.93	0.93	1.05	1.05	1.34	1.87

(1) BASED ON DATA EXTRAPOLATED FROM HIGHWAY LAND COSTS AND EXPRESSED IN TERMS OF TWO-TRACK RAIL FACILITIES WHERE AT GRADE AND OPEN CUT RIGHTS-OF-WAY CROSS SECTIONS AVERAGE 36 FEET AND ELEVATED, CUT AND COVER, AND TUNNELING CROSS SECTIONS AVERAGE 30 FEET.

NOTE: CAUTION IS ESPECIALLY WARRANTED IN USING THE FIGURE FOR CBD LOCATION IN SMSA'S WITH POPULATIONS OVER ONE MILLION SINCE THERE IS A WIDE VARIATION IN ACTUAL VALUES.

SOURCE: BHATT, K., "CAPACITY AND COST INPUTS FOR COMMUNITY AGGREGATE PLANNING MODEL (CAPM)", THE URBAN INSTITUTE, WASHINGTON, D.C., DECEMBER, 1973

SKINNER, L., _COSTING URBAN TRANSPORTATION ALTERNATIVES_, U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, WASHINGTON, D.C.

TABLE 2-20

RAIL RAPID CONSTRUCTION COSTS

LOCATION/TYPE	FACILITY: LINE ($ MILLION/MI)	FACILITY: STATION ($ MILLION)
INTENSE DEVELOPMENT		
CUT AND COVER	87.4	12.2
ROCK TUNNEL	37.3	7.4
EARTH TUNNEL	37.8	---
ELEVATED	13.0	4.0
AVERAGE DEVELOPMENT		
CUT AND COVER	60.9	9.9
ROCK TUNNEL	21.5	3.7
EARTH TUNNEL	28.9	---
SURFACE	11.1	3.6
SPARSE DEVELOPMENT		
CUT AND COVER	25.1	9.5
ELEVATED	6.7	3.0
SURFACE	3.3	2.0

NOTE: ABOVE COSTS ARE BASED ON TWO-TRACK SYSTEMS WITH 600-FOOT STATIONS. 1976 COST DATA.

TUNNELING COSTS VARY GREATLY WITH GEOLOGICAL CONDITIONS.

SOURCE: SKINNER, L., COSTING URBAN TRANSPORTATION ALTERNATIVES, U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, WASHINGTON, D.C.

TABLE 2-21

LIGHT RAIL TRANSIT CONSTRUCTION COSTS
(PER MILE)

FACILITY TYPE	DEFAULT VALUE ($MILLION)	RANGE OF VALUES ($MILLION)
AT GRADE	1.2	0.4-2.0
ELEVATED	13.4	7.9-19.2
BORED TUNNEL(1)	VARIES WITH GEOLOGIC CONDITIONS	
STATION (EACH)		
AT GRADE	0.1	0.0-0.2
ELEVATED	2.0	0.9-3.2
SUBWAY	13.4	11.8-14.8

(1) COSTS VARY GREATLY WITH GEOLOGIC CONDITIONS. RESEARCH UNDERWAY IS REPORTED TO YIELD RELATIONSHIPS THAT CAN BE PRESENTED IN FUTURE UPDATES OF THIS HANDBOOK.

NOTE: ABOVE COSTS ARE EXPRESSED IN TERMS OF 1976 PRICES AND ARE BASED ON A TWO-TRACK SYSTEM. THEY HAVE BEEN PROJECTED FROM A 1973 BASE USING THE ENGINEERING NEWS RECORD GENERAL CONSTRUCTION INDEX. LINE COSTS DO NOT INCLUDE STATIONS OR RIGHTS-OF-WAY.

SOURCE: KRZYCAKOWSKI, R., AND HENNEMAN, S., <u>CRITERIA FOR FUNDING URBAN RAIL TRANSIT SYSTEMS</u>, INTERPLAN CORPORATION, MARCH, 1974

TABLE 2-22

SAMPLE RAIL RAPID TRANSIT ROLLING STOCK COSTS
(1969-1974)

MANUFACTURER (PURCHASER)	SEATS	WEIGHT (TONS)	COST	SIZE OF ORDER	DATE OF ORDER
CANADIAN VICKERS (MUCT)	40	30	$354,609	423	1974
BOEING VERTOL (CTA)	48-50	23	$316,000	100	1974
HAWKER-SIDDELEY (TTC)	78	28	$288,665	88	1973
ROHR (BART)	72	29	$390,000	100	1973
BOEING VERTOL (CTA)	48-50	23	$294,000	100	1973
PULLMAN (MBTA)	60-64	31	$230,132	80	1973
PULLMAN (NYCTA)	70-76	43-45	$275,381	745	1972
ROHR (BART)	72	29	$370,000	100	1972
ROHR (WMATA)	80	36	$305,333	300	1972
HAWKER-SIDDELEY (TTC)	83	28	$155,945	76	1971
PULLMAN (CTS)	80	32	$251,950	10	1970
HAWKER-SIDDELEY (PATH)	35	30	$191,304	46	1970
GENERAL STEEL (NYCTA)	72-76	42-44	$206,595	300	1969
ROHR (BART)	72	29	$268,000	250	1969

SOURCE: RAIL TRANSIT CAR COSTS: A REVIEW ANALYSIS AND PROJECTIONS, SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS, LOS ANGELES, CALIFORNIA, MAY, 1975.

TABLE 2-23

SAMPLE COMMUTER RAIL TRANSIT ROLLING STOCK COSTS
(1972-1975)

MANUFACTURER (PURCHASER)	SEATS	WEIGHT (TONS)	COST	SIZE OF ORDER	DATE OF ORDER
---- (E. L.)	70	51	$478,125 (EST.)	160	1975
HAWKER-SIDDELEY (G. O.)	94	34	$241,152	30	1975
GENERAL ELECTRIC (READING)	129	38	$728,000	70	1975
HAWKER-SIDDELEY (G. O.)	94	34	$200,960	30	1973
BUDD (CABS)	155	64	$372,000	2	1973
BUDD (TRAILERS) (CMSTPP)	161	60	$352,000	3	1973
GENERAL ELECTRIC (NH/M. T. A.)	120	46	$639,000	100	1973
GENERAL ELECTRIC/ BUDD (L. I./M. T. A.)	120	46	$300,000	150	1973
BUDD (CABS)	139	67	$416,118	20	1972
BUDD (TRAILERS) (BN)	145	65	$378,166	5	1972
GENERAL ELECTRIC/ BUDD (P. C./M. T. A.)	122	46	$312,000	50	1972
PULLMAN (CABS)	104	37	$258,000	11	1972
PULLMAN (TRAILERS) (E. L.)	108	37	$218,000	39	1972
GENERAL ELECTRIC/ BUDD (P. C./M. T. A.)	122	46	$245,000	48	1972
GERNERAL ELECTRIC (READING)	129	64	$388,888	14	1972

SOURCE: RAIL TRANSIT CAR COST: A REVIEW ANALYSIS AND PROJECTIONS, SOUTHERN CALIFORNIA ASSOCIATION OF GOVERNMENTS, LOS ANGELES, CALIFORNIA, MAY, 1975.

TABLE 2-24

SAMPLE LIGHT RAIL TRANSIT ROLLING STOCK COSTS

TYPE OF CAR (PURCHASER)	SEATS	AXLES	COST(1)	NO. OF CARS ACQUIRED	DATE
ASEA (MELBOURNE)	48	4	$120,000	100	MARCH, 1973
DUWAG RHEIN (GERMANY)	72	6	$481,000	28(2)	UNKNOWN
TATRA K2 (CZECHOSLOVAKIA)	49	6	$113,000-$121,000	329(2)	UNKNOWN
TATRA KT4D (CZECHOSLOVAKIA)	26-38	4	$108,000-$119,000	2	UNKNOWN
U. S. STANDARD LIGHT RAIL	68	6	$328,000	150	1973

(1) UNIT COSTS DEPEND ON NUMBER OF CARS ORDERED, PASSENGER AMENITIES, SIZE, ELECTRONIC EQUIPMENT, ETC.
(2) TOTAL CARS IN USE.

SOURCE: LIGHT RAIL TRANSIT, LEA TRANSIT COMPENDIUM, VOLUME 1, NUMBER 5, HUNTSVILLE, ALABAMA, 1974
UNPUBLISHED DATA, OFFICE OF TRANSIT ASSISTANCE, UMTA

NOTE: 1976 BID PRICES FOR LIGHT RAIL TRANSIT CARS ARE GENERALLY IN THE $6-800,000 RANGE.

TABLE 2-25

RAIL RAPID TRANSIT ACCIDENTS - VEHICLE AND PASSENGER (1971-1972)

VALUE	YEAR	TRANSIT ACCIDENTS (PER MILLION TRAIN MILES) (1)	ON-BOARD PASSENGER INJURIES (PER MILLION TRAIN MILES) (2)	IN-STATION PASSENGER INJURIES (PER MILLION TRAIN MILES) (3)	TOTAL PASSENGER INJURIES (FATALITIES) (PER MILLION TRAIN MILES) (4,5,6)
DEFAULT	1971	2.84	35.64	128.64	164.28(.7004)
RANGE	1971	1.24-17.80	12.04-57.44	44.04-192.56	56.08-250.00
DEFAULT	1972	3.00	29.92	124.00	153.92(.7004)
RANGE	1972	0.84-18.88	6.84-53.68	42.52-190.72	49.36-244.40

(1) INCLUDES VEHICLE ACCIDENTS WHICH INVOLVE COLLISION WITH PEDESTRIANS, COLLISION WITH OTHER VEHICLES AND OBJECTS, DERAILMENTS, AND ACCIDENTS INVOLVING THIRD RAILS/OVERHEAD WIRES, ETC.; BASED ON 4 CARS PER TRAIN.

(2) INCLUDES PASSENGER ACCIDENTS AND FATALITIES WHICH INVOLVE BOARDING/ALIGHTING, DOOR RELATED, AND ALL ON-BOARD INCIDENTS; SEPARATE FATALITY COUNT FOR THIS CATEGORY NOT AVAILABLE; BASED ON 4 CARS PER TRAIN.

(3) INCLUDES PASSENGER ACCIDENTS AND FATALITIES WHILE OFF TRAIN BUT WHILE ON: STAIRS, ESCALATORS, MEZZANINES, TURNSTILES, CORRIDORS/PASSAGES, PLATFORMS, TRACKS, AND ALL OTHERS; SEPARATE FATALITY COUNT NOT AVAILABLE FOR THIS CATEGORY; BASED ON 4 CARS PER TRAIN.

(4) INCLUDES TOTAL ACCIDENTS OCCURRING ON AND OFF TRAIN WITH FATALITIES INCLUDED IN DATA BUT SEPARATELY DEFINED; BASED ON 4 CARS PER TRAIN.

(5) NUMBERS IN PARENTHESES ARE PASSENGER FATALITIES; SEE NOTE BELOW.

(6) THE INJURY AND FATALITY ACCIDENT RATES ARE MUTUALLY EXCLUSIVE, I.E. FATAL ACCIDENTS ARE NOT INCLUDED IN INJURY CALCULATIONS.

NOTE: ABOVE DATA BASED ON FOLLOWING RAIL RAPID TRANSIT SYSTEMS: PATH, MTA, CTA, MBTA, SEPTA, TTC AND MUCTC; INJURIES TO PERSONS OTHER THAN PASSENGERS ARE NOT INCLUDED.

ABOVE DATA INCLUDE PASSENGER FATALITIES. FOR A SEPARATE INVENTORY OF FATALITY RATES THE FOLLOWING MAY BE USED: PASSENGER FATALITIES IN TRANSIT VEHICLES (0.0336 PER MILLION CAR MILES) AND PASSENGER FATALITIES NOT ON TRANSIT VEHICLES (.6668 PER MILLION CAR MILES). THESE RATES ARE BASED ON AN ANALYSIS OF EIGHT TRANSIT PROPERTIES (CTA, CTS, MBTA, MTA, PATH, PATCO, SEPTA, AND BART) FOR 1972 AND 1973, AND ARE BASED ON 4 CARS PER TRAIN.

SOURCES: AMERICAN PUBLIC TRANSIT ASSOCIATION, ACCIDENT SUMMARY REPORTS, WASHINGTON, D.C., 1971-1972

INSTITUTE FOR RAPID TRANSIT, MONTHLY ACCIDENT AND INJURY REPORTS, WASHINGTON, D.C., 1972-1973

TABLE 2-26

COMMUTER RAIL ACCIDENTS
(1971-74)

COMMUTER RAIL COMPANY	TOTAL ACCIDENTS: REPORTED FATALITIES	REPORTED INJURIES	PASSENGER MILES (MILLIONS)	RATES PER MILLION PASSENGER MI: FATALITIES	INJURIES
BOSTON AND MAINE	---	11	341.8	---	.0322
CENTRAL RAILROAD OF NEW JERSEY	1	35	449.1	.0022	.0779
LONG ISLAND	5	228	6669.9	.0007	.0342
PENN CENTRAL	19	441	6662.0	.0029	.0662
ERIE-LACKAWANNA	4	128	1348.2	.0030	.0949
CHICAGO AND NORTH WESTERN	1	42	2112.1	.0005	.0199
READING COMPANY	2	45	751.8	.0027	.0599
SOUTHERN PACIFIC	16	162	587.2	.0272	.2759
CHICAGO, ROCK ISLAND & PACIFIC	3	54	465.5	.0064	.1160
DEFAULT VALUE				.0026	.0591

NOTE: DOES NOT INCLUDE INJURIES AND FATALITIES TO EMPLOYEES OR OTHER PERSONS INVOLVED WHO ARE NOT PASSENGERS.

FATAL ACCIDENTS ARE NOT INCLUDED IN INJURY RATE CALCULATIONS.

INJURY RATE FOR PASSENGERS MAY BE LOWER FOR NEW SYSTEMS SINCE MANY OF THE ABOVE ACCIDENTS WERE CAUSED BY DEFECTS IN EQUIPMENT/MAINTENANCE OF ROLLING STOCK AND STRUCTURES. ABOVE ACCIDENTS CAUSED BY NEGLIGENCE OF EMPLOYEES (7.6 PERCENT); DEFECTS OR EQUIPMENT FAILURES (21.4 PERCENT); IMPROPER MAINTENANCE (15.1 PERCENT); AND OTHER (55.9 PERCENT).

SOURCE: FEDERAL RAILROAD ADMINISTRATION, SUMMARY AND ANALYSIS OF ACCIDENTS ON RAILROADS IN THE UNITED STATES, ACCIDENT BULLETINS 140-143, U.S. DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., 1971-75

TABLE 2-27

LIGHT RAIL TRANSIT ACCIDENTS
(1971-73)

VALUE	YEAR	TRANSIT ACCIDENTS (PER MILLION TRAIN MILES) (1) COLLISION	DERAILMENT	OTHER	TOTAL
DEFAULT	1971	124.05	4.62	1.02	129.69
RANGE	1971	61.82-193.65	0.73-6.63	0.74-1.23	63.29-201.51
DEFAULT	1972	147.14	6.57	0.87	154.58
RANGE	1972	60.86-227.06	0.74-10.59	0.61-1.11	62.21-238.76
DEFAULT	1973	155.82	6.51	4.31	166.64
RANGE	1973	51.51-243.99	5.65-13.22	0.31-13.22	57.47-270.43

VALUE	YEAR	PASSENGER ACCIDENTS (PER MILLION TRAIN MILES) (2) BOARDING/ ALIGHTING	STRUCK BY DOORS	ON-BOARD	TOTAL
DEFAULT	1971	17.14	7.20	21.68	46.02
RANGE	1971	4.80-29.48	2.13-12.28	7.90-35.46	14.83-77.22
DEFAULT	1972	21.16	6.09	34.82	62.07
RANGE	1972	3.44-38.88	1.63-10.54	8.49-61.15	13.56-110.57
DEFAULT	1973	7.29	5.96	25.95	39.20
RANGE	1973	3.71-10.87	3.49-8.42	7.45-44.45	14.65-63.74

(1) INCLUDES ALL VEHICLE ACCIDENTS WHILE CONDUCTING REVENUE OR NON-REVENUE SERVICE; BASED ON ANALYSIS OF 4 TRANSIT PROPERTIES: BOSTON, PHILADELPHIA, TORONTO, AND NEW ORLEANS.

(2) INCLUDES ALL PASSENGER ACCIDENTS WHILE CONDUCTING REVENUE SERVICE; USED TOTAL MILES; BASED ON LIGHT RAIL IN TORONTO AND NEW ORLEANS.

NOTE: SEPARATE INFORMATION ON FATAL ACCIDENTS IS NOT AVAILABLE. HOWEVER, THESE RATES INCLUDE FATAL ACCIDENTS. ABOVE ANALYSIS ASSUMES 1 CAR PER TRAIN FOR LIGHT RAIL.

SOURCE: AMERICAN TRANSIT ASSOCIATION (NOW APTA), COMPARATIVE OPERATING ACCIDENT RATES, WASHINGTON, D.C., 1971-72

CHAPTER III

LOCAL BUS AND BUS RAPID TRANSIT

THIS CHAPTER CONTAINS A SET OF QUANTITATIVE VALUES FOR THE SEVEN SUPPLY PARAMETERS SELECTED TO CHARACTERIZE MOTORIZED BUS TRANSPORT: SPEED, CAPACITY, OPERATING COST, ENERGY CONSUMPTION, POLLUTANT EMISSIONS, CAPITAL COST, AND ACCIDENT FREQUENCY. IN SOME CASES, BUSES HAVE BEEN TREATED WITHOUT REGARD TO VARIATIONS IN SIZE AND FUNCTION. THIS IS NOT TRUE IN RELATION TO SPEED, CAPACITY, ENERGY CONSUMPTION, AND POLLUTANT EMISSION, WHERE SOME DISTINCTIONS ARE MADE ACCORDING TO BUS TYPE AND FUNCTION. APPENDIX C SHOULD BE CONSULTED FOR MORE DETAILED AND SPECIFIC INFORMATION.

TABLE 3-1

TYPICAL BUS SPEEDS

TYPE OF SERVICE	SPEED (MPH) PEAK	OFF-PEAK
LOCAL BUS (SMALL CITY) ON COLLECTOR STREET	10	12
LOCAL BUS (LARGE CITY) ON COLLECTOR STREET	5	7
LOCAL BUS IN BUS LANE ON COLLECTOR STREET(1)	8	10(2)
LOCAL BUS ON ARTERIAL STREET(3)	10-11	13-15
LOCAL BUS ON ARTERIAL RESERVED LANE(4)	15	17(5)
EXPRESS BUS ON FREEWAY	30	45
EXPRESS BUS IN FREEWAY BUS LANE	45	45(6)

(1) DATA REFLECT SPEEDS IN LARGE SIZED CITIES: RESERVED CURB, MEDIAN, AND CONTRA-FLOW BUS LANES AS WELL AS BUS STREETS.

(2) NOT USUALLY OPERATED IN OFF-PEAK HOURS; ESTIMATED AT 10 MPH.

(3) DATA REFLECT SPEEDS IN SMALL AND LARGE SIZED CITIES.

(4) DATA REFLECT SPEEDS IN LARGE SIZED CITIES: RESERVED CURB, MEDIAN, AND CONTRA-FLOW BUS LANES.

(5) NOT USUALLY OPERATED IN OFF-PEAK HOURS; ESTIMATED AT 17 MPH.

(6) NOT USUALLY OPERATED IN OFF-PEAK HOURS; ESTIMATED AT 45 MPH.

NOTE: SEE TABLES C-1 AND C-2 FOR SITE SPECIFIC SPEEDS ON BUS LANES.

SOURCES: LEVINSON, H., HUEY, W., SANDERS, D., WYNN, H., <u>BUS USE OF HIGHWAYS: STATE OF THE ART</u>, NATIONAL COOPERATIVE HIGHWAY RESEARCH REPORT 143, WASHINGTON, D.C., 1973

LEVINSON, H., AND SANDERS, D., <u>RESERVED BUS LANES ON URBAN FREEWAYS: A MACRO MODEL</u>, HIGHWAY RESEARCH BOARD, WASHINGTON, D.C., JANUARY, 1974

AMERICAN TRANSIT ASSOCIATION (NOW APTA), <u>TRANSIT OPERATING REPORTS</u>, WASHINGTON, D.C., 1971-1972

TABLE 3-2

BUS SERVICE VOLUME PER LANE
THEORETICAL AND OBSERVED

TYPE OF CONDITION	NUMBER OF BUSES (PER HOUR)	HEADWAY (SECONDS)	NUMBER(1) OF PERSONS (PER HOUR)	THEORETICAL OR OBSERVED
UNINTERRUPTED FLOW ON TEST TRACK(A)	1450	2.5	72,500	OBSERVED (2)
HIGHWAY CAPACITY MANUAL FREEWAY - LEVEL OF SERVICE D (A)	940	3.8	47,000	THEORETICAL
DOT - CHERNIACK ITE (1963) (A)	720	5.0	36,000	THEORETICAL (3)
HIGHWAY CAPACITY MANUAL FREEWAY - LEVEL OF SERVICE C (A)	690	5.1	34,500	THEORETICAL
I-495 EXCLUSIVE BUS LANE (NEW YORK-NEW JERSEY) (A)	490	7.4	26,350	OBSERVED
ARTERIAL BUS LANE(B)	170	21.2	8,500	OBSERVED (4)
CBD CURB BUS LANE(B)	160-120	23.0-30.0	8,000-6,000	OBSERVED (5)
BUS LANE - ON LINE STOPS(B)	120	30.0	6,000	THEORETICAL (6)
HIGHWAY CAPACITY MANUAL - ARTERIAL BUS LANE (B)	120	30.0	6,000	THEORETICAL
CBD BUS STREETS, CONTRA FLOW, MEDIAN LANES (B)	100	36.0	5,000	OBSERVED (7)

(1) ASSUMING A CAPACITY OF 50 PERSONS PER BUS.

(2) OBSERVED AT THE GENERAL MOTORS PROVING GROUNDS UNDER IDEAL CONDITIONS; NO TRAFFIC FLUCTUATION AND PERFECT GEOMETRICS, 1964.

(3) THEORETICAL POLICY ESTABLISHED IN 1963.

(4) ON HILLSIDE AVENUE, QUEENS, NEW YORK.

(5) HIGHEST RECORDED TO DATE.

(6) 20 SECOND ON-LINE STOPS, 10 SECOND STATION CLEARANCE, PERFECT HEADWAY GEOMETRICS.

(7) HIGHEST RECORDED TO DATE.

(A) THESE OPERATIONS DO NOT INCLUDE ON-LINE BUS STOPS.

(B) THESE OPERATIONS INCLUDE ON-LINE BUS STOPS.

NOTE: ABOVE DATA REPRESENT ONE LANE ONLY.

SEE TABLE 3-4 FOR SERVICE VOLUME ON A BUS PLATFORM UNDER PLATOON OPERATIONS.

SOURCE: LEVINSON, H., HOEY, W., SANDERS, D., WYNN H., <u>BUS USE OF HIGHWAYS: STATE OF THE ART</u>, NATIONAL COOPERATIVE HIGHWAY RESEARCH REPORT 143, WASHINGTON, D.C., 1973

TABLE 3-3

BUS AND PASSENGER SERVICE VOLUMES AT BUS BOARDING STOPS

TYPE OF FARE PAYMENT	BUS LOADING CONDITION (1)	CUMULATIVE TOTAL PASSENGERS PER HOUR — NUMBER OF BERTHS (2)				CUMULATIVE TOTAL BUSES PER HOUR — NUMBER OF BERTHS (3)			
		1	2	3	4	1	2	3	4
PAY UPON BOARDING -1 DOOR AVAILABLE	ON-LINE	650	1140	1460	1620	13	23	30	33
	OFF-LINE	650	1200	1750	2240	13	24	35	45
PREPAYMENT -1 DOOR AVAILABLE	ON-LINE	950	1660	2140	2380	19	34	43	48
	OFF-LNE	950	1760	2570	3280	19	36	52	66
PREPAYMENT -2 DOORS AVAILABLE	ON-LINE	1550	2710	3490	3830	31	54	70	77
	OFF-LINE	1550	2870	4190	5350	31	58	84	107

(1) ON-LINE LOADING: PASSENGERS BOARD BUSES WHILE THE BUSES ARE STILL IN THE MAIN ROADWAY; OFF-LINE LOADING: BUS BERTHS LOCATED OFF THE MAIN ROADWAY WHERE A BUS, ONCE LOADED, CAN PULL OUT AND INTO THE TRAFFIC STREAM.

(2) PASSENGER RATES ACCOUNT FOR EXPECTED INTERNAL IMPEDANCES, PEAK 20-MINUTE DEMAND, INEFFICIENCIES IN BERTH LOADING CAPABILITIES.

(3) BASED ON 50 PASSENGERS PER BUS.

SOURCE: WILBUR SMITH AND ASSOCIATES, "DESIGN AND ANALYSIS OF BUS AND TRUCK ROADWAY SYSTEMS IN URBAN AREAS," DRAFT REPORT, NEW HAVEN, CONNECTICUT, NOVEMBER, 1973

TABLE 3-4

SERVICE VOLUME OF A BUS LOADING PLATFORM
UNDER PLATOON OPERATION

MAXIMUM SPEED OF BUS PLATOON (MPH)	DWELL TIME (SECONDS)	NUMBER OF BUSES IN PLATOON: 4(1)	8(2)	12(3)
		BUS SERVICE VOLUME (SEATED PASSENGERS PER HOUR)		
30	20	304(6080)	464(9280)	552(11040)
30	40	220(8800)	360(14400)	456(18240)
60	20	240(4800)	360(7200)	456(9120)
60	40	184(7360)	288(11520)	360(14400)

(1) ASSUMES FOUR BUSES PER PLATOON CAPABLE OF BOARDING ONE RIDER PER SECOND.
(2) ASSUMES EIGHT BUSES PER PLATOON CAPABLE OF BOARDING ONE RIDER PER SECOND.
(3) ASSUMES TWELVE BUSES PER PLATOON CAPABLE OF BOARDING ONE RIDER PER SECOND.

NOTE: USUALLY BUS PASSENGERS KNOW WHERE TO STAND AT THE PLATFORM AND ARE ENCOURAGED TO FORM WAITING LINES TO MINIMIZE BOARDING DELAY.

TABLE 2-5 (FOR RAIL TRANSIT) IS ANALOGOUS TO THE ABOVE TABLE; BUS CAPACITY, WHEN ON-LINE STOPS ARE INCLUDED, IS RESTRAINED BY THE BOARDING TIME IF LOADING OCCURS THROUGH A NORMAL SIZED DOOR; RAIL CAPACITY IS CONSTRAINED BY ON-LINE CONDITIONS SUCH AS STATION SPACING, ACCELERATION, MAXIMUM SPEED, ETC.

SOURCE: GENERAL MOTORS RESEARCH LABORATORIES, <u>BUS OPERATIONS IN SINGLE LANE PLATOONS AND THEIR VENTILATING NEEDS FOR OPERATIONS IN TUNNELS</u>, GMR-808, WARREN, MICHIGAN, 1968

TABLE 3-5

BUS OPERATING COSTS

POPULATION SERVICE AREA	OPERATION COST PER BUS MILE			
	DEFAULT	2-SIGMA RANGE	ENTIRE RANGE	NUMBER
OVER 2,500,000	$2.09	$1.25- $2.95	$1.13- $3.74	9
750,000- 2,500,000	$1.49	$1.28- $2.70	$1.15 $2.12	24
100,000- 750,000	$1.11	$0.79- $1.42	$0.63- $1.56	39
UNDER 100,000	$0.88	$0.75- $1.00	$0.56- $1.00	13

NOTE: COST ELEMENTS: MAINTENANCE OF GARAGE AND EQUIPMENT, 18%; TRANSPORTATION, 57%; STATION AND ADVERTISING, 2%; INSURANCE AND SAFETY, 6%; GENERAL AND ADMINISTRATIVE, 11%; TAXES AND RENTS, 6%. DATA DO NOT INCLUDE DEPRECIATION OR INTEREST.

DATA PROJECTED FROM A 1975 BASE TO A 1976 LEVEL USING THE CONSUMER PRICE INDEX.

SOURCE: AMERICAN PUBLIC TRANSIT ASSOCIATION, TRANSIT OPERATING REPORT, WASHINGTON, D.C., 1976

TABLE 3-6

BUS FUEL CONSUMPTION FOR LARGE SIZED BUSES
(GALLONS PER VEHICLE-MILE)

VEHICLE SPEED (MPH)	ROADWAY GRADE (PER CENT)			
	0	2	3	5
5	0.446	0.552	0.606	0.775
10	0.251	0.327	0.376	0.485
15	0.193	0.268	0.313	0.408
20	0.167	0.247	0.290	0.386
25	0.156	0.241	0.288	0.403
30	0.154	0.202	0.317	N/A
35	0.095	0.173	N/A	N/A
40	0.108	0.186	N/A	N/A
45	0.123	0.206	N/A	N/A

NOTES: ABOVE DATA BASED ON STANDARD GMC 51-SEAT PASSENGER BUS EQUIPPED WITH STANDARD DIESEL ENGINE (6Y71N/C5I).

SEE TABLE C-3 FOR SPECIFIC BUS ECONOMIC AND PERFORMANCE CHARACTERISTICS.

SOURCE: GENERAL MOTORS CORPORATION TRUCK AND COACH DIVISION, "VEHICLE DYNAMICS SIMULATION MODEL," PONTIAC, MICHIGAN, 1974

TABLE 3-7

FUEL CONSUMPTION FOR MINI AND MID-SIZED BUSES
(GALLONS PER VEHICLE-MILE)

VEHICLE SPEED (MPH)	FUEL CONSUMPTION ON LEVEL ROADWAY	
	MINIBUS(1)	MIDSIZE(2)
5	0.437	0.222
10	0.474	0.128
15	0.266	0.105
20	0.134	0.091
25	0.139	0.078
30	0.149	0.072
35	0.158	0.079
40	0.168	0.082
45	0.119	0.089
50	0.132	0.093
55	0.143	0.102
60	0.155	0.107

(1) ABOVE DATA BASED ON STANDARD GMC VAN EQUIPPED WITH 12 SEATS AND A GASOLINE ENGINE (MODEL 366).

(2) ABOVE DATA BASED ON MIDSIZE GMC 33-SEAT PASSENGER BUS EQUIPPED WITH A DIESEL ENGINE (DH 478).

SOURCE: GENERAL MOTORS CORPORATION TRUCK AND COACH DIVISION, "VEHICLE DYNAMICS SIMULATION MODEL," PONTIAC, MICHIGAN, 1974

TABLE 3-8

BUS FUEL CONSUMPTION
(PER VEHICLE-MILE)
(1973)

TYPE OF BUS TRIP	TYPICAL RANGE (MILES)	AVERAGE DISTANCE (MILES)	BUS SIZE	TYPE OF FUEL	FUEL CONSUMPTION (GALLONS PER VEHICLE MILE)	TOTAL FUEL CONSUMPTION PER TRIP (GALLONS)
RESIDENTIAL COLLECTION/ DISTRIBUTION	1.0-5.0 (1)	3.0 (1)	JITNEY - 5 PASSENGERS	GASOLINE	0.093	0.279
			BUS WAGON - 8 PASSENGERS	GASOLINE	0.111	0.333
			MINIBUS - 19 PASSENGERS	GASOLINE	0.154	0.462
			NORMAL BUS - 50 PASSENGERS	DIESEL	0.193 (4)	0.579
LINE HAUL						
SURFACE ARTERIAL	1.5-5.0 (2,3)	2.0 (2,3)	BUS CARRYING 50 PASSENGERS	DIESEL	0.167 (5)	0.334
EXCLUSIVE BUSWAY	7.0-9.0 (2,3)	8.0 (2,3)	BUS CARRYING 50 PASSENGERS	DIESEL	0.123 (6)	0.984
CBD COLLECTION/ DISTRIBUTION	1.0-6.0 (1)	3.0 (1)	NORMAL BUS - 50 PASSENGERS	DIESEL	0.251 (7)	0.753

(1) MEYER, J.R., KAIN, J.F., AND WOHL, M., THE URBAN TRANSPORTATION PROBLEM, HARVARD UNIVERSITY PRESS, CAMBRIDGE, MASSACHUSETTS, 1966.

(2) WILBUR SMITH AND ASSOCIATES, FUTURE HIGHWAYS AND URBAN GROWTH, NEW HAVEN, CONNECTICUT, 1961.

(3) LEVINSON, H., HOEY, W., SANDERS, D., WYNN, H., BUS USE OF HIGHWAYS: STATE OF THE ART, NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM, REPORT 143, WASHINGTON, D.C., 1973.

(4) ASSUMES AN AVERAGE SPEED OF 15 MPH.

(5) ASSUMES AN AVERAGE SPEED OF 25 MPH.

(6) ASSUMES AN AVERAGE SPEED OF 45 MPH.

(7) ASSUMES AN AVERAGE SPEED OF 10 MPH.

NOTE: AN AVERAGE TRIP USING A NORMAL BUS AND INVOLVED IN RESIDENTIAL AND CBD COLLECTION/DISTRIBUTION AND LINE HAUL (ON AN EXCLUSIVE BUSWAY) WOULD USE 2.316 GALLONS OF DIESEL FUEL OVER A TOTAL DISTANCE OF 14.0 MILES.

SEE TABLE C-3 FOR SPECIFIC BUS ECONOMIC AND PERFORMANCE CHARACTERISTICS.

SOURCES: WELLS, J., ASHER, N., FLOWERS, M., ET AL, ECONOMIC CHARACTERISTICS OF THE URBAN PUBLIC TRANSPORTATION INDUSTRY, INSTITUTE FOR DEFENSE ANALYSES, FEBRUARY, 1972

GENERAL MOTORS CORPORATION, TRUCK AND COACH DIVISION, "VEHICLE DYNAMICS SIMULATION MODEL," PONTIAC, MICHIGAN, 1974

TABLE 3-9

BUS POLLUTANT EMISSIONS
(1973)

TYPE OF TRIP RANGE OF TRIP BUS SIZE	TYPE OF FUEL	POLLUTANTS CARBON MONOXIDE GR/MI	HYDRO-CARBONS GR/MI	OXIDES OF NITROGEN GR/MI
RESIDENTIAL				
1-5 MI TRIPS(1)				
5 PASS(4)	GSL	68.95	9.53	4.54
8 PASS(4)	GSL	94.46	13.06	6.22
19 PASS(4)	GSL	119.97	16.58	7.90
50 PASS(5)	DSL	10.90	14.70	13.84
LINE HAUL				
1.5-5 MI TRIPS(2,3)				
SURFACE ARTERIAL BUS ON ARTERIAL STREET, MIXED TRAFFIC--50 PASS(5)	DSL	10.90	14.70	13.84
7-9 MI TRIPS(2,3)				
EXCLUSIVE BUSWAY BUS ON EXCLUSIVE BUSWAY--50 PASS (CRUISE ONLY)	DSL	10.54 (5)	11.69 (6)	8.53 (6)
CBD				
1-6 MI TRIPS(1)				
NORMAL BUS--50 PASS(5)	DSL	10.90	14.70	13.84

(1) MEYER, J.R., KAIN, J.E., AND WOHL, M., THE URBAN TRANSPORTATION PROBLEM, HARVARD UNIVERSITY PRESS, CAMBRIDGE, MASSACHUSETTS, 1966.

(2) WILBUR SMITH AND ASSOCIATES, "FUTURE HIGHWAYS AND URBAN GROWTH," NEW HAVEN, CONNECTICUT, 1961.

(3) LEVINSON, H., HOEY, W., SANDERS, D., WYNN, H., BUS USE OF HIGHWAYS: STATE OF THE ART, NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT 143, WASHINGTON, D.C., 1973

(4) ESTIMATED FROM TRANS-AUTOMOBILE DATA ASSUMING 20 MPH SPEED LIMIT AND ADJUSTING FOR APPROXIMATE VEHICLE WEIGHT.

(5) ESTIMATED FROM WELLS, J.D., ET AL, ECONOMIC CHARACTERISTICS OF THE URBAN PUBLIC TRANSPORTATION INDUSTRY, INSTITUTE FOR DEFENSE ANALYSES, ARLINGTON, VIRGINIA, FEBRUARY, 1972, USING A SPEED OF 25 MPH.

(6) SAME AS (5) EXCEPT WITH A SPEED OF 45 MPH.

NOTE: POLLUTION RATES ARE FOR 1973; AFTER 1975 THESE MUST BE CHECKED TO ENSURE RATES MEET EPA GUIDELINES.

TO OBTAIN TOTAL POLLUTANTS EMITTED, THE GRAMS PER MILE PER POLLUTANT CAN BE MULTIPLIED BY THE AVERAGE DISTANCE THE BUS TRAVELS.

SOURCE: WELLS, J., ASHER N., FLOWERS, M., ET AL, ECONOMIC CHARACTERISTICS OF THE URBAN PUBLIC TRANSPORTATION INDUSTRY, INSTITUTE FOR DEFENSE ANALYSES, FEBRUARY,1972

TABLE 3-10

BUSWAY LAND COSTS
(MILLIONS OF DOLLARS PER MILE)

	POPULATION GROUPS (1000'S)					
LOCATION(1)	UNDER 50	50-100	100-250	250-500	500-1000	OVER 1000
CBD	1.15	1.15	1.37	1.72	2.30	2.54
FRINGE	1.15	1.15	1.24	1.37	1.72	2.29
RESIDENTIAL	1.02	1.02	1.15	1.15	1.47	2.04

(1) THESE ESTIMATES ARE BASED ON LAND NEEDED FOR TWO 12-FOOT WIDE BUS LANES, 8-FOOT SHOULDERS ON EACH SIDE, AND A ONE-FOOT MEDIAN (TOTAL CROSS SECTION 41 FEET). SMALLER CROSS SECTIONS WOULD COST PROPORTIONATELY LESS.

NOTE: LAND COSTS ESTIMATED FROM TYPICAL URBAN FREEWAY LAND COSTS AND ADJUSTED TO REFLECT BUSWAY CROSS SECTION REQUIREMENTS; EXPRESSED IN TERMS OF 1976 COSTS.

SOURCE: BHATT, K.,"CAPACITY AND COST INPUTS FOR COMMUNITY APPROACH PLANNING MODEL (CAPM)," THE URBAN INSTITUTE, WASHINGTON, D.C., DECEMBER, 1973

SKINNER, L., COSTING URBAN TRANSPORTATION ALTERNATIVES, U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, WASHINGTON, D.C., FORTHCOMING, 1977

TABLE 3-11

BUSWAY CONSTRUCTION COST - AT GRADE FACILITY
(MILLIONS OF DOLLARS PER MILE)

	POPULATION GROUPS (1000'S)					
LOCATION(1)	UNDER 50	50-100	100-250	250-500	500-1000	OVER 1000
CBD	3.38	3.38	3.48	3.57	3.70	4.03
FRINGE	2.31		2.44	2.64	3.05	3.89
RESIDENTIAL	2.01	2.01	2.01	2.11	2.31	2.72

(1) THESE ESTIMATES ARE BASED ON THE COST OF CONSTRUCTION REQUIRED FOR TWO 12-FOOT WIDE BUS LANES, 8-FOOT SHOULDERS ON EACH SIDE, AND A ONE-FOOT MEDIAN (TOTAL CROSS SECTION 41 FEET). SMALLER CROSS SECTIONS WOULD COST PROPORTIONATELY LESS.

NOTE: CONSTRUCTION COSTS ESTIMATED FROM TYPICAL URBAN FREEWAY LAND COSTS AND ADJUSTED TO REFLECT BUSWAY CROSS SECTION REQUIREMENTS; PROJECTED FROM A 1973 BASE TO 1976 USING THE FEDERAL HIGHWAY ADMINISTRATION COMPOSITE CONSTRUCTION INDEX. DOES NOT INCLUDE LAND COSTS (SEE TABLE 3-10) OR STATION COSTS (ESTIMATED AT $200-300,000 EACH).

SEE TABLE C-4 FOR SPECIFIC EXISTING OR PROPOSED BUSWAY CONSTRUCTION COSTS BY LOCATION.

SOURCES: BHATT, K., "CAPACITY AND COST INPUTS FOR COMMUNITY AGGREGATE PLANNING MODEL (CAPM)," THE URBAN INSTITUTE, WASHINGTON, D.C., DECEMBER, 1973

WILBUR SMITH AND ASSOCIATES, "DESIGN AND ANALYSIS OF BUS AND TRUCK ROADWAY SYSTEMS IN URBAN AREAS," PHASE I, NEW HAVEN, CONNECTICUT, NOVEMBER, 1973

TABLE 3-12

BUSWAY CONSTRUCTION COST - UNDERGROUND FACILITY
(MILLION $ PER MILE)

STATION FREQUENCY PER MILE	SHALLOW CUT AND COVER ON-LINE(2)	SHALLOW CUT AND COVER OFF-LINE(3)	CUT AND COVER WITH MEZZANINE ON-LINE(2)	CUT AND COVER WITH MEZZANINE OFF-LINE(3)	BORED TUNNEL
1	32.9	33.7	40.3	41.2	
2	33.9	35.4	41.5	42.7	
3	35.0	37.5	42.7	44.5	
4	36.0	39.6	43.9	46.6	

TYPE OF CONSTRUCTION(1)

(1) THESE ESTIMATES ARE BASED ON A TWO-LANE BUSWAY WITH NO MEDIAN OR ADJACENT SHOULDERS; APPROXIMATE CROSS SECTION IS 24 FEET. COSTS INCLUDE VENTILATION AND LIGHTING, ROADWAY, STATION, AND CONTINGENCIES (AT 15 PERCENT OF COST).

(2) BUS STOPS ARE ALONG THE MAIN ALIGNMENT.

(3) BUS STOPS ARE OFF THE MAIN ALIGNMENT.

NOTE: PROJECTED FROM A 1973 BASE TO 1976 USING THE ENGINEERING NEWS RECORD GENERAL CONSTRUCTION INDEX. DOES NOT INCLUDE LAND COSTS (SEE TABLE 3-10).

THE ABOVE DATA REFLECTS A SMALLER CROSS SECTION WIDTH THAN SOME OF THE PRECEDING TABLES; CARE MUST BE EXERCISED IN ASSIGNING AN AVERAGE SPEED TO THIS TYPE OF FACILITY, SINCE BUSES WILL BE OPERATING WITHOUT THE ADVANTAGE OF SHOULDERS AND MEDIAN STRIPS.

SOURCE: WILBUR SMITH AND ASSOCIATES, "DESIGN AND ANALYSIS OF BUS AND TRUCK ROADWAY SYSTEMS IN URBAN AREAS," NEW HAVEN, CONNECTICUT, NOVEMBER, 1973

TABLE 3-13

IMPLEMENTATION AND OPERATING COSTS FOR RESERVED FREEWAY BUS LANES

FACILITY	LENGTH (MILES)	START-UP COSTS ($)	ANNUAL(1) OPERATING COSTS ($)
S. E. BOSTON EXPRESSWAY	8.4	45,000	183,000
I-495 (NEW YORK-NEW JERSEY)	2.5	917,000(2)	262,000
LONG ISLAND EXPRESSWAY	2.0	66,000	196,000
SAN FRANCISCO-OAKLAND BAY BRIDGE	1.0	76,000	16,000
MARIN COUNTY CORRIDOR (US-101)	5.0	262,000	---
SEATTLE BLUE STREAK (I-5)	8.5	769,000	---

(1) ANNUAL OPERATING COSTS INCLUDE ONLY THE COSTS OF PROVIDING THE FACILITY; THEY DO NOT INCLUDE VEHICLE OPERATING COSTS.

(2) INCLUDES SOPHISTICATED TRAFFIC SIGNALS AND IMPROVED PARKING FACILITIES.

NOTE: ALL RESERVED FREEWAY BUS LANES ARE LABOR INTENSIVE IN THAT MAINTENANCE, POLICE, AND SAFETY CREWS ARE NEEDED TO OPEN AND CLOSE THE BUS LANES DURING THE HOURS OF OPERATION. PRICES ARE PROJECTED 1976 DOLLARS, USING THE CONSUMER PRICE INDEX.

SOURCE: LEVINSON, H., HOEY, W., SANDERS, D., WYNN, H., BUS USE OF HIGHWAYS: STATE OF THE ART, NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT 143, WASHINGTON, D.C., 1973

TABLE 3-14

CAPITAL COSTS OF MOTOR BUSES

TYPE OF BUS	DEFAULT VALUE	RANGE OF VALUES
JITNEY 5 PASSENGERS	$ 8,000	$ ---
BUS WAGON 10 PASSENGERS	16,000	13,000 - 20,000
MINIBUS 15-20 PASSENGERS	28,000	23,000 - 38,000
MIDSIZE BUS 25-33 PASSENGERS	44,000	34,000 - 38,000
NORMAL BUS 40-41 PASSENGERS	56,000	44,000 - 68,000
LARGE NORMAL BUS 47-51 PASSENGERS	66,000	50,000 - 70,000
ARTICULATED BUS 70 PASSENGERS	167,000	---

NOTE: COSTS VARY ACCORDING TO NUMBER OF VEHICLES ORDERED, INTERIOR FINISH, ENGINE SPECIFICATIONS, AND AIR CONDITIONING CAPACITY.

SOURCE: UNPUBLISHED OFFICE OF TRANSIT ASSISTANCE DATA ON 263 BUS PURCHASES FROM OCTOBER 1971 TO MARCH 1977 PROJECTED TO A 1976 COST BASIS.

TABLE 3-15

BUS VEHICLE ACCIDENTS (PASSENGER ACCIDENTS)
PER MILLION BUS MILES
(1971-1972)

VALUE	POPULATION RANGE (1000'S) 0-100	100-250	250-500	500-1000	OVER 1000
DEFAULT	82.55 (12.20)	56.60 (16.13)	58.84 (17.15)	48.16 (18.76)	67.16 (21.50)
RANGE	.03- 254.07	19.21- 154.42	18.99- 93.54	3.91- 111.83	16.23- 108.14
	(0.83- 37.42)	(3.78- 34.40)	(0.42- 109.24)	(1.82- 49.24)	(5.61- 33.94)

NOTE: ABOVE DEFAULT VALUES ARE WEIGHTED AVERAGES (WEIGHTED BY THE TOTAL LINE-MILES OPERATED BY EACH COMPANY).

BUS TRAFFIC ACCIDENTS INCLUDE COLLISIONS WITH PEDESTRIANS, OTHER BUSES, VEHICLES, AND MISCELLANEOUS OBJECTS.

BUS PASSENGER ACCIDENTS INCLUDE ACCIDENTS INVOLVING BOARDING, ALIGHTING, DOOR-RELATED, AND ALL RECORDED ON-BOARD ACCIDENTS; FATALITIES ARE INCLUDED.

FATALITIES PER MILLION BUS-MILES OPERATED IS APPROXIMATELY 0.088; THIS FIGURE REPRESENTS ABOUT TWO-THIRDS OF ALL TRANSIT MILES OPERATED IN THE UNITED STATES, INCLUDING ZONE AT-GRADE RAILROAD TROLLEY TYPE OPERATIONS.

SEE TABLES C-5 AND C-6 FOR VARIATION ON ACCIDENT STATISTICS BY YEAR (1971-72).

SOURCES: AMERICAN PUBLIC TRANSIT ASSOCIATION, <u>ACCIDENT OPERATING STATISTICS</u>, WASHINGTON, D.C., 1971-1972

NATIONAL SAFETY COUNCIL, <u>ACCIDENT FACTS</u>, CHICAGO, ILLINOIS, 1965-72

CHAPTER IV

AUTOMOBILE-HIGHWAY SYSTEM

THIS CHAPTER CONTAINS A SET OF QUANTITATIVE VALUES FOR SELECTED SUPPLY PARAMETERS USED TO CHARACTERIZE AUTOMOBILE-HIGHWAY SYSTEMS (I.E., AUTOMOBILE AND TRUCK TRAFFIC): SPEED, CAPACITY, OPERATING COST, ENERGY CONSUMPTION, POLLUTANT EMISSIONS, CAPITAL COST, AND ACCIDENT FREQUENCY. IN MOST CASES THIS SECTION PRESENTS MEASURES FOR AUTOMOBILES, TRUCKS, AND FOR A MIXED TRAFFIC STREAM. APPENDIX D CONTAINS SUPPORTING MATERIAL AND MORE SPECIFIC AUTOMOBILE-HIGHWAY SYSTEM INFORMATION.

TABLE 4-1

MAJOR ASSUMPTIONS IN CALCULATING
CAPACITY AND AVERAGE SPEED
AS SHOWN IN TABLE 4-2

FACILITY TYPE	LOCATION			
	CENTRAL BUSINESS DISTRICT	FRINGE	RESIDEN-TIAL	OUTLYING BUSINESS DISTRICT
FREEWAY	UNINTERRUPTED FLOW 3 LANES EACH DIRECTION 12-FOOT LANE WIDTH 4-FOOT LATERAL CLEARANCE 5 PERCENT TRUCKS ROLLING TERRAIN PEAK HOUR FACTOR--0.85 50 MPH DESIGN SPEED		70 MPH DESIGN SPEED	60 MPH DESIGN SPEED
EXPRESS-WAY	3 LANES EACH DIRECTION 11-FOOT LANE WIDTH 5 PERCENT THRU BUSES 10 PERCENT TURNS CYCLE LENGTH-- 90 SECONDS PEAK HOUR FACTOR--0.85 ACCELERATION-- 4 MPHPS AMBER TIME-- 5 SECONDS 50 MPH DESIGN SPEED 2 SIGNALS/MILE (G/C-.65)	1 SIGNAL/MILE (G/C-.75)	1 SIGNAL/MILE (G/C-.75) 60 MPH DESIGN SPEED	2 SIGNALS/ MILE (G/C-.65) 50 MPH DESIGN SPEED

ARTERIAL TWO-WAY WITH PARKING	5 PERCENT TRUCKS 10 PERCENT TURNS (BOTH) CYCLE LENGTH-- 60 SECONDS PEAK HOUR FACTOR--0.85 FAR SIDE BUS STOPS MAXIMUM SPEED-- 25 MPH 5 SIGNALS/MILE (G/C-.55) 22-FOOT APPROACH WIDTH UP TO 50 BUSES/HOUR	MAXIMUM SPEED --30 MPH 3 SIGNALS/ MILE (G/C-.60) 24-FOOT APPROACH WIDTH UP TO 70 BUSES/HOUR	MAXIMUM SPEED --35 MPH 2 SIGNALS/ MILE (G/C-.65) 20-FOOT APPROACH WIDTH	MAXIMUM SPEED --25 MPH 3 SIGNALS/ MILE (G/C-.60) 24-FOOT APPROACH WIDTH
ARTERIAL TWO-WAY WITHOUT PARKING	UP TO 35 BUSES/HOUR MAXIMUM SPEED --25 MPH 5 SIGNALS/MILE (G/C-.55) 22-FOOT APPROACH WIDTH	22-FOOT APPROACH WIDTH MAXIMUM SPEED --30 MPH UP TO 50 BUSES/HOUR 3 SIGNALS/ MILE (G/C-.60)	20-FOOT APPROACH WIDTH MAXIMUM SPEED --35 MPH 2 SIGNALS/ MILE (G/C-.65)	22-FOOT APPROACH WIDTH MAXIMUM SPEED --25 MPH 3 SIGNALS/ MILE (G/C-.60)
ARTERIAL ONE-WAY	44-FOOT APPROACH WIDTH NO PARKING UP TO 65 BUSES/HOUR MAXIMUM SPEED --25 MPH 5 SIGNALS/MILE (G/C-.51)	40-FOOT APPROACH WIDTH PARKING ONE SIDE MAXIMUM SPEED --30 MPH UP TO 75 BUSES/HOUR 3 SIGNALS/ MILE (G/C-.60)	30-FOOT APPROACH WIDTH PARKING ONE SIDE MAXIMUM SPEED 35 MPH 2 SIGNALS/ MILE (G/C-.65)	30-FOOT APPROACH WIDTH PARKING BOTH SIDES MAXIMUM SPEED --25 MPH UP TO 110 BUSES/HOUR 3 SIGNALS MILE (G/C-.60)

NOTE: ALL DATA BASED ON 1,000,000 POPULATION.

THE ASSUMPTIONS FOR EACH FACILITY TYPE (FREEWAY, EXPRESSWAY, AND ARTERIAL) ARE LISTED ONLY ONCE UNLESS THE ASSUMPTION(S) CHANGES; I.E., THE TABLE IS READ HORIZONTALLY BY FACILITY; ALL CLASSES OF ARTERIALS ARE TREATED SIMILARLY.

SOURCE: BASED ON ASSUMPTIONS FROM HIGHWAY RESEARCH BOARD, HIGHWAY CAPACITY MANUAL, 1965, WASHINGTON, D.C., 1965

TABLE 4-2

CAPACITY AND AVERAGE SPEED ON VARIOUS ROADWAYS PER LANE

FACILITY TYPE	LOCATION							
	CENTRAL BUSINESS DISTRICT		FRINGE		RESIDENTIAL		OUTLYING BUSINESS DISTRICT	
	CAPACITY(1) 1750 VPH		CAPACITY(1) 1750 VPH		CAPACITY(1) 1750 VPH		CAPACITY(1) 1750 VPH	
	V/C	SPEED (MPH) (2)	V/C	SPEED (MPH) (2)	V/C	SPEED (MPH) (2)	V/C	SPEED (MPH) (2)
FREEWAY	0.00	48	0.00	48	0.00	67	0.00	58
	0.50	38	0.50	38	0.50	57	0.50	48
	0.75	33	0.75	33	0.75	50	0.75	41
	1.00	28	1.00	28	1.00	34	1.00	30
	800 VPH		1000 VPH		1100 VPH		1000 VPH	
EXPRESSWAY	0.00	37	0.00	44	0.00	47	0.00	37
	0.50	34	0.50	38	0.50	44	0.50	34
	0.75	33	0.75	35	0.75	41	0.75	33
	1.00	31	1.00	32	1.00	38	1.00	31
	400 VPH		550 VPH		550 VPH		550 VPH	
ARTERIAL TWO-WAY WITH PARKING	0.00	17-22	0.00	25-29	0.00	28-32	0.00	22-24
	0.50	17-20	0.50	20-27	0.50	25-30	0.50	20-22
	0.75	15-15	0.75	18-25	0.75	23-28	0.75	18-18
	1.00	12-12	1.00	15-15	1.00	15-15	1.00	13-13
	600 VPH		800 VPH		800 VPH		800 VPH	
ARTERIAL TWO-WAY WITHOUT PARKING	0.00	17-22	0.00	25-29	0.00	28-32	0.00	22-24
	0.50	17-20	0.50	20-27	0.50	25-30	0.50	20-22
	0.75	15-15	0.75	18-25	0.75	23-28	0.75	18-18
	1.00	12-12	1.00	15-15	1.00	15-15	1.00	13-13
	700 VPH		550 VPH		900 VPH		650 VPH	
ARTERIAL ONE-WAY	0.00	17-22	0.00	25-29	0.00	28-32	0.00	22-24
	0.50	17-20	0.50	20-27	0.50	25-30	0.50	20-22
	0.75	15-15	0.75	18-25	0.75	23-28	0.75	18-18
	1.00	12-12	1.00	15-15	1.00	15-15	1.00	13-13

(1) CAPACITY CALCULATED AT LEVEL OF SERVICE E; ABSOLUTE CAPACITY.

(2) FIRST VALUE SHOWS SPEED ASSUMING LACK OF COORDINATED SIGNAL PROGRESSION; SECOND VALUE SHOWS SPEED ASSUMING FULL SIGNAL PROGRESSION.

NOTE: SEE TABLE 4-1 FOR MAJOR ASSUMPTIONS.

SEE TABLES D-1 TO D-5 IN THE APPENDIX AND FIGURE D-1 IN THE CUTS MANUAL FOR DETAILED CAPACITY CALCULATIONS OF ARTERIAL STREETS.

SOURCE: BASED ON HIGHWAY RESEARCH BOARD, HIGHWAY CAPACITY MANUAL, 1965, WASHINGTON, D.C., 1965

TABLE 4-3

VEHICLE OPERATING COST ON FREEWAYS (1)
(CENTS PER VEHICLE MILE)

	AVERAGE SPEED (MPH)							
VEHICLE	60	55	50	45	40	35	30	25
SUBCOMPACT	6.36	5.92	5.67	5.42	5.36	5.25	5.20	5.23
COMPACT	7.65	7.09	6.78	6.49	6.39	6.28	6.22	6.24
STANDARD AUTO	9.58	8.93	8.56	8.19	8.07	7.93	7.85	7.87
2 TON TRUCK	11.18	10.35	9.84	9.38	9.22	9.11	8.93	8.94
6 TON TRUCK	22.20	20.58	19.26	17.89	17.13	16.50	15.84	15.48
20 TON (GASOLINE) TRUCK	51.02	46.53	43.91	39.68	39.19	36.63	34.79	33.47
25 TON (DIESEL) TRUCK	58.43	49.48	46.02	42.16	40.67	38.96	36.89	35.57
COMPOSITE VEHICLE(2)	12.34	11.34	10.77	10.15	9.92	9.67	9.44	9.36

(1) DATA ARE BASED ON TYPICAL ROADWAY SEGMENTS WHICH REFLECT VARIOUS CURVES, GRADES, SLOWDOWNS, STOPS, ETC.
STATE AND FEDERAL TAXES ARE NOT INCLUDED IN THESE COSTS; A FUEL PRICE OF 52.4 CENTS PER GALLON IS ASSUMED. THE EFFECTS OF ADDING TAXES OR OTHER PRICE CHANGES CAN BE DETERMINED BY MULTIPLYING THE FUEL CONSUMPTION RATE IN TABLE 4-5 BY THE PRICE DIFFERENCE AND ADDING THE RESULTS TO THOSE PRESENTED HERE.

(2) COMPOSITE VEHICLE IS MADE UP OF 48.16% STANDARD, 24.92% COMPACT, 9.96% SUBCOMPACT, 6.81% TWO-TON TRUCKS, 3.26% SIX TON TRUCKS, 3.29% TWENTY TON TRUCKS, AND 3.60% TWENTY-FIVE TON TRUCKS.

NOTE: DATA ARE FROM A 1974 BASE UPDATED TO 1976 USING THE CONSUMER PRICE INDEX OVERALL PRIVATE TRANSPORT INDEX. COSTS INCLUDE MAINTENANCE, TIRES, OIL, GASOLINE, AND TRAVEL RELATED DEPRECIATION.

SOURCE: BLOOM, KENT, <u>TRANS-URBAN COMPUTER MODEL (OPGAS)</u>, FEDERAL HIGHWAY ADMINISTRATION, U.S. DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., APRIL, 1973

TABLE 4-4

VEHICLE OPERATING COST ON ARTERIALS(1)

	COST - CENTS PER MILE (2)				
AVERAGE SPEED (MPH)	35	30	25	20	15
SUBCOMPACT	9.15	9.10	8.90	8.47	8.53
COMPACT	10.95	10.92	10.65	10.15	10.22
STANDARD AUTO	13.81	13.76	13.43	12.79	12.87
2 TON TRUCK	16.01	15.81	15.36	14.58	14.59
6 TON TRUCK	31.20	30.66	30.52	23.74	26.86
20 TON (GASOLINE) TRUCK	87.34	84.94	79.57	75.64	68.82
25 TON (DIESEL) TRUCK	100.10	97.34	90.92	86.52	77.60
COMPOSITE VEHICLE (3)	15.64	15.48	14.98	14.13	14.08

(1) DATA ARE BASED ON TYPICAL ROADWAY SEGMENTS WHICH REFLECT VARIOUS CURVES, GRADES, SLOWDOWNS, STOPS, ETC.

(2) STATE AND FEDERAL TAXES ARE NOT INCLUDED IN THESE COSTS; A FUEL PRICE OF 52.4 CENTS PER GALLON IS ASSUMED IN THESE CALCULATIONS. THE EFFECTS OF ADDING TAXES OR OTHER PRICE CHANGES CAN BE DETERMINED BY MULTIPLYING THE FUEL CONSUMPTION RATE IN TABLE 4-6 BY THE PRICE DIFFERENCE AND ADDING THE RESULTS TO THOSE PRESENTED HERE.

(3) COMPOSITE VEHICLE IS MADE UP OF 10% SUBCOMPACT, 25% COMPACT, 48.32% STANDARD, 10.41% TWO TON TRUCKS, 3.56% SIX TON TRUCKS, 1.44% TWENTY TON TRUCKS, AND 1.27% TWENTY-FIVE TON TRUCKS.

NOTE: DATA ARE FROM A 1972 BASE UPDATED TO 1976 USING THE CONSUMER PRICE INDEX OVERALL PRIVATE TRANSPORT INDEX. COSTS INCLUDE MAINTENANCE, TIRES, OIL, GASOLINE, AND DEPRECIATION.

SOURCE: BLOOM, KENT, TRANS-URBAN COMPUTER MODEL (OPGAS), FEDERAL HIGHWAY ADMINISTRATION, U.S. DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., APRIL, 1973

TABLE 4-5

VEHICLE GASOLINE CONSUMPTION ON FREEWAYS
(GALLONS PER VEHICLE MILE)

VEHICLE	AVERAGE SPEED (MPH)								
	65	60	55	50	45	40	35	30	25
SUBCOMPACT AUTOMOBILE	.0497	.0453	.0420	.0395	.0379	.0371	.0358	.0354	.0356
COMPACT AUTOMOBILE	.0667	.0608	.0563	.0531	.0504	.0498	.0481	.0475	.0478
STANDARD AUTOMOBILE	.0825	.0752	.0696	.0656	.0623	.0616	.0594	.0587	.0591
2 TON LIGHT DUTY TRUCK	.0999	.0851	.0740	.0663	.0608	.0577	.0522	.0549	.0554
6 TON SINGLE UNIT TRUCK	.1437	.1347	.1259	.1200	.1158	.1148	.1147	.1152	.1173
20 TON GASOLINE TRUCK	.3500	.3554	.3332	.2799	.2985	.2968	.2963	.2970	.3052
25 TON DIESEL TRUCK	.2339	.2382	.2289	.2188	.2102	.2094	.2076	.2056	.2062
MIXED VEHICLE(2)	.0927	.0864	.0801	.0743	.0716	.0707	.0687	.0683	.0690

(1) DATA BASED ON TYPICAL ROADWAY SEGMENTS WHICH REFLECT VARIOUS CURVES, GRADES, STOPS PER MILE, TRAFFIC DENSITIES, ETC.
(2) DATA BASED ON VEHICLE MIX OF 83.04% AUTOMOBILES, 6.81% TWO TON TRUCKS, 3.26% SIX TON TRUCKS, 3.29% TWENTY TON TRUCKS, 3.60% TWENTY-FIVE TON TRUCKS. THE AUTOMOBILE MIX IS 58%, 30%, AND 12% FOR STANDARD, COMPACT, AND SUBCOMPACT, RESPECTIVELY.

SOURCE: BLOOM, KENT, TRANS-URBAN COMPUTER MODEL (OPGAS), FEDERAL HIGHWAY ADMINISTRATION, U.S. DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., APRIL, 1973

TABLE 4-6

VEHICLE GASOLINE CONSUMPTION ON ARTERIAL STREETS
(1974)

AVERAGE SPEED (MPH)	CONSUMPTION - GALLONS PER MILE (1)						
	45	40	35	30	25	20	15
SUBCOMPACT AUTOMOBILE	.0544	.0540	.0538	.0543	.0540	.0522	.0529
COMPACT AUTOMOBILE	.0730	.0724	.0721	.0729	.0724	.0701	.0710
STANDARD AUTOMOBILE	.0902	.0895	.0892	.0901	.0895	.0866	.0877
2 TON LIGHT DUTY TRUCK	.0811	.0782	.0726	.0791	.0786	.0774	.0804
6 TON SINGLE UNIT TRUCK	.1697	.1709	.1787	.1854	.1873	.1830	.1853
20 TON GASOLINE TRUCK	.5434	.5385	.5553	.5639	.5559	.5268	.5378
25 TON DIESEL TRUCK	.3663	.3656	.3782	.3867	.3801	.3572	.3462
MIXED VEHICLE(2)	.0941	.0933	.0931	.0950	.0943	.0910	.0924

(1) DATA BASED ON TYPICAL ROADWAY SEGMENTS WHICH REFLECT VARIOUS CURVES, GRADES, STOPS PER MILE, TRAFFIC DENSITIES, ETC.
(2) DATA BASED ON VEHICLE MIX OF 83.32% AUTOMOBILES, 10.41% TWO TON TRUCKS, 3.56% SIX-TON TRUCKS, 1.44% TWENTY TON TRUCKS, AND 1.27% TWENTY-FIVE TON TRUCKS. THE AUTOMOBILE MIX IS 58% FOR STANDARD, 30% FOR COMPACT, AND 12% FOR SUBCOMPACT.

SOURCE: BLOOM, KENT, TRANS-URBAN COMPUTER MODEL (OPGAS), FEDERAL HIGHWAY ADMINISTRATION, U.S. DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., APRIL, 1973

TABLE 4-7(A)

COMPOSITE POLLUTANT EMISSION FACTORS (1977)
FREEWAYS AND SURFACE ARTERIALS (1)

	AUTOS			TRUCKS (2)		
SPEED (MPH)	CARBON MONOXIDE	HYDRO-CARBONS(3)	OXIDES OF NITROGEN	CARBON MONOXIDE	HYDRO-CARBONS(3)	OXIDES OF NITROGEN
	(GRAMS PER MILE)			(GRAMS PER MILE)		
60.0	24.13	4.10	4.88	65.96	6.59	13.19
55.0	28.75	4.40	4.32	61.75	6.74	11.51
50.0	30.40	4.51	4.04	59.02	6.85	10.44
45.0	31.60	4.61	3.89	58.59	7.06	9.75
40.0	33.93	4.79	3.80	61.08	7.48	9.28
35.0	38.02	5.09	3.68	66.92	8.15	8.93
30.0	44.00	5.52	3.52	76.61	9.16	8.65
25.0	51.88	6.08	3.31	91.16	10.62	8.44
20.0	62.41	6.83	3.08	112.97	12.81	8.35
15.0	79.37	8.04	2.90	148.12	16.38	8.48

NOTE: THESE NOTES APPLY TO ALL 4-7 TABLES (A) THROUGH (D)

(1) EMISSIONS INCLUDE COLD STARTS, HOT SOAKS, HOT OPERATION, AND DIURNAL EVAPORATION.

(2) THE ASSUMED TRUCK VEHICLE MIX IS 30.2% LIGHT DUTY TRUCKS (≤6000 LBS.), 30.2% LIGHT DUTY TRUCKS (>6000 LBS.), 23.4% HEAVY DUTY TRUCKS (GASOLINE), AND 16.1% HEAVY DUTY TRUCKS (DIESEL). THE MIX OF AUTOS BY TYPE IS AS IN MOBIL1. IN COMPUTING A COMPOSITE VEHICLE, THE OVERALL VEHICLE MIX MAY BE ASSUMED 80.2% AUTOS AND 19.2% TRUCKS.

(3) HYDROCARBON EMISSIONS INCLUDE REACTIVE HYDROCARBONS ONLY: METHANE EXCLUDED.

NOTE: THE FOLLOWING PARAMETERS WERE USED IN GENERATING THESE FACTORS:

TEMPERATURE	:75 DEGREES
COLD START(NON-CATALYST) VMT	:18.4% OF NON-CATALYST AUTO VMT
HOT START(NON-CATALYST) VMT	:20.0% OF NON-CATALYST AUTO VMT
HOT STABILIZED(NON-CATALYST) VMT	:61.6% OF NON-CATALYST AUTO VMT
COLD START(CATALYST) VMT	:26.0% OF CATALYST AUTO VMT
HOT START(CATALYST) VMT	:12.4% OF CATALYST AUTO VMT
HOT STABILIZED(CATALYST) VMT	:61.6% OF CATALYST AUTO VMT

SOURCE: ENVIRONMENTAL PROTECTION AGENCY, "MOBILE SOURCE EMISSION FACTORS," WASHINGTON, DC, MARCH 1978.

TABLE 4-7(B)

COMPOSITE POLLUTANT EMISSION FACTORS (1982)
FREEWAYS AND SURFACE ARTERIALS (1)

SPEED (MPH)	AUTOS CARBON MONOXIDE	AUTOS HYDRO-CARBONS(3)	AUTOS OXIDES OF NITROGEN	TRUCKS (2) CARBON MONOXIDE	TRUCKS (2) HYDRO-CARBONS(3)	TRUCKS (2) OXIDES OF NITROGEN
	(GRAMS PER MILE)			(GRAMS PER MILE)		
60.0	14.37	1.97	3.59	58.96	4.35	13.52
55.0	18.20	2.16	3.15	58.42	4.51	11.24
50.0	19.39	2.24	2.93	57.61	4.61	9.82
45.0	19.90	2.29	2.82	57.95	4.79	8.93
40.0	21.14	2.39	2.75	60.51	5.12	8.34
35.0	23.65	2.57	2.65	65.84	5.67	7.93
30.0	27.51	2.82	2.52	74.35	6.48	7.64
25.0	32.60	3.16	2.34	86.62	7.66	7.47
20.0	39.03	3.60	2.15	104.07	9.38	7.45
15.0	48.69	4.28	1.99	130.82	12.11	7.70

TABLE 4-7(C)

COMPOSITE POLLUTANT EMISSION FACTORS (1987)
FREEWAYS AND SURFACE ARTERIALS (1)

SPEED (MPH)	AUTOS CARBON MONOXIDE	AUTOS HYDRO-CARBONS(3)	AUTOS OXIDES OF NITROGEN	TRUCKS (2) CARBON MONOXIDE	TRUCKS (2) HYDRO-CARBONS(3)	TRUCKS (2) OXIDES OF NITROGEN
	(GRAMS PER MILE)			(GRAMS PER MILE)		
60.0	7.99	0.92	2.81	39.21	2.08	10.16
55.0	10.26	1.04	2.46	40.33	2.24	8.41
50.0	10.93	1.09	2.29	40.46	2.35	7.33
45.0	11.15	1.12	2.20	40.93	2.48	6.65
40.0	11.78	1.17	2.14	42.73	2.72	6.19
35.0	13.12	1.28	2.07	46.35	3.11	5.87
30.0	15.22	1.43	1.96	52.02	3.69	5.64
25.0	17.96	1.64	1.81	59.99	4.51	5.49
20.0	21.35	1.90	1.65	70.90	5.69	5.45
15.0	26.31	2.29	1.52	87.05	7.48	5.61

TABLE 4-7(D)

COMPOSITE POLLUTANT EMISSION FACTORS (1995)
FREEWAYS AND SURFACE ARTERIALS (1)

SPEED (MPH)	AUTOS CARBON MONOXIDE	AUTOS HYDRO-CARBONS(3)	AUTOS OXIDES OF NITROGEN	TRUCKS (2) CARBON MONOXIDE	TRUCKS (2) HYDRO-CARBONS(3)	TRUCKS (2) OXIDES OF NITROGEN
	(GRAMS PER MILE)			(GRAMS PER MILE)		
60.0	6.06	0.67	2.56	26.48	0.97	6.52
55.0	7.71	0.78	2.32	27.56	1.10	5.56
50.0	8.19	0.81	2.15	27.82	1.19	4.96
45.0	8.35	0.84	2.07	28.14	1.31	4.58
40.0	8.80	0.89	2.01	29.24	1.50	4.31
35.0	9.77	0.97	1.94	31.44	1.81	4.09
30.0	11.28	1.10	1.84	34.88	2.28	3.91
25.0	13.25	1.27	1.70	39.64	2.97	3.75
20.0	15.68	1.49	1.55	45.91	3.94	3.64
15.0	19.22	1.81	1.42	54.74	5.38	3.63

TABLE 4-8(A)

POLLUTANT EMISSION FACTOR COMPONENTS (1) (1977)

A. EMISSIONS FROM HOT STABILIZED OPERATION
FREEWAYS AND SURFACE ARTERIALS

	AUTOS			TRUCKS (2)		
SPEED (MPH)	CARBON MONOXIDE	HYDRO-CARBONS(3)	OXIDES OF NITROGEN	CARBON MONOXIDE	HYDRO-CARBONS(3)	OXIDES OF NITROGEN
	(GRAMS PER MILE)			(GRAMS PER MILE)		
60.0	19.11	1.87	4.72	65.96	4.17	13.19
55.0	22.64	2.14	4.23	61.75	4.32	11.51
50.0	24.08	2.25	3.97	59.02	4.43	10.44
45.0	25.30	2.33	3.83	58.59	4.64	9.75
40.0	27.49	2.50	3.73	61.08	5.08	9.28
35.0	31.15	2.78	3.63	66.92	5.73	8.93
30.0	36.44	3.17	3.48	76.61	6.74	8.65
25.0	43.48	3.68	3.30	91.16	8.20	8.44
20.0	53.11	4.37	3.09	112.06	10.39	8.35
15.0	68.94	5.47	2.92	148.12	13.96	8.48

B. EMISSIONS FROM AUTO STARTS

PERCENT OF TRIPS STARTING COLD(4)	EMISSIONS CARBON MONOXIDE	HYDRO-CARBONS(3)	OXIDES OF NITROGEN
	GRAMS PER TRIP		
0	15.5	3.9	4.6
10	33.6	4.9	4.6
20	51.9	5.9	4.6
30	69.9	6.9	4.5
40	89.0	7.8	4.5
50	107.	8.8	4.4
60	126.	9.8	4.4
70	143.	10.7	4.4
80	161.	11.7	4.3
90	180.	12.7	4.3
100	198.	13.6	4.3

C. OTHER EMISSIONS

1.	HOT SOAK EMISSIONS (HC)	: 11.8 G/AUTO TRIP
2.	DIURNAL EVAPORATIVE EMISSIONS (HC)	: 19.4 G/AUTO/DAY
3.	DIURNAL EVAPORATIVE EMISSIONS (HC)	: 21.0 G/TRUCK/DAY

NOTE: THESE NOTES APPLY TO ALL 4-8 TABLES (A) THROUGH (D)

(1) MOBILE SOURCE EMISSIONS ARE GENERATED IN FOUR WAYS:

1. FROM VEHICLES TRAVELING IN HOT, STABILIZED MODE; THAT IS, AFTER THE ENGINE AND CATALYTIC CONVERTER (IF ANY) HAVE WARMED UP TO THEIR MOST EFFICIENT OPERATING TEMPERATURE RANGE. (CO, HC, AND NOX EMISSIONS.)
2. FROM VEHICLE STARTS; ADDITIONAL EMISSIONS ARISE WHEN AN ENGINE IS STARTED, REGARDLESS OF THE TRAVEL DISTANCE. (CO, HC, AND NOX EMISSIONS.)
3. FROM HOT SOAKS; WHEN AN ENGINE IS TURNED OFF, HYDRO-CARBONS ARE EVAPORATED FROM UNBURNED FUEL IN THE CRANKCASE (HC ONLY).
4. FROM DIURNAL EVAPORATION; DAILY TEMPERATURE CYCLES CAUSE EVAPORATION OF HYDROCARBONS FROM FUEL TANKS, WHETHER OR NOT THE VEHICLES ARE USED. (HC ONLY)

PREVIOUS EMISSIONS ESTIMATES HAVE BASED ALL FACTORS SOLELY ON VMT (AS IN TABLE 4-7). A MORE SATISFACTORY APPROACH IS TO COMPUTE EACH COMPONENT SEPARATELY USING DATA IN TABLE 4-8. NOTE THAT THE COMPONENTS EMPLOY DIFFERENT BASES:

* HOT OPERATION EMISSIONS ARE PER VMT
* VEHICLE START EMISSIONS ARE PER TRIP
* HOT SOAK EMISSIONS ARE PER TRIP
* DIURNAL EMISSIONS ARE PER VEHICLE

THE MIX OF AUTOS AND TRUCKS IS AS IN TABLES 4-7.

(2) BECAUSE OF DATA LIMITATIONS, IT IS CURRENTLY IMPOSSIBLE TO SPLIT TRUCK START-UP AND HOT SOAK EMISSIONS FROM HOT STABILIZED EMISSIONS. THEREFORE, THESE TRUCK FACTORS INCLUDE THREE COMPONENTS, EXCLUDING ONLY DIURNAL EMISSIONS.

(3) HYDRO CARBON EMISSIONS INCLUDE REACTIVE HYDROCARBONS ONLY; METHANE IS EXCLUDED.

(4) FOR VEHICLES WITH CATALYTIC CONVERTERS, ANY ENGINE STARTED MORE THAN ONE HOUR SINCE ITS LAST OPERATION IS CLASSIFIED IN THE COLD START MODE. FOR NON-CATALYTIC VEHICLES, THE INTERVAL IS 4 HOURS. IN THE ABSENCE OF LOCAL DATA, A DEFAULT VALUE OF 53 PERCENT COLD STARTS MAY BE USED FOR 1977. THIS VALUE INCREASES WITH CALENDAR YEAR AS THE AUTO FLEET IS INCREASINGLY POPULATED BY CATALYST-EQUIPPED VEHICLES.

NOTE: ALL FACTORS HAVE BEEN COMPUTED FOR AN ASSUMED TEMPERATURE OF 75 DEGREES FAHRENHEIT.

SOURCES: ENVIRONMENTAL PROTECTION AGENCY, "MOBILE SOURCE EMIS-

SION FACTORS," WASHINGTON, DC; MARCH 1978.

FEDERAL HIGHWAY ADMINISTRATION, "HOW TO PREPARE THE TRANSPORTATION PORTION OF YOUR STATE AIR QUALITY IMPLEMENTATION PLAN," WASHINGTON, DC; NOVEMBER 1978.

TABLE 4-8(B)

POLLUTANT EMISSION FACTOR COMPONENTS (1) (1982)

A. EMISSIONS FROM HOT STABILIZED OPERATION
FREEWAYS AND SURFACE ARTERIALS

SPEED (MPH)	AUTOS: CARBON MONOXIDE	AUTOS: HYDRO-CARBONS(3)	AUTOS: OXIDES OF NITROGEN	TRUCKS (2): CARBON MONOXIDE	TRUCKS (2): HYDRO-CARBONS(3)	TRUCKS (2): OXIDES OF NITROGEN
	(GRAMS PER MILE)			(GRAMS PER MILE)		
60.0	8.32	0.61	3.19	58.96	2.97	13.52
55.0	11.89	0.78	2.82	58.42	3.13	11.24
50.0	12.96	0.84	2.62	57.61	3.23	9.82
45.0	13.20	0.88	2.51	57.95	3.41	8.93
40.0	14.02	0.96	2.44	60.51	3.74	8.34
35.0	15.95	1.09	2.35	65.84	4.29	7.93
30.0	19.10	1.29	2.23	74.35	5.10	7.64
25.0	23.29	1.56	2.07	86.62	6.28	7.47
20.0	28.38	1.89	1.88	104.07	8.00	7.45
15.0	35.53	2.38	1.69	130.82	10.73	7.70

B. EMISSIONS FROM AUTO STARTS

PERCENT OF TRIPS STARTING COLD(4)	EMISSIONS: CARBON MONOXIDE	EMISSIONS: HYDRO-CARBONS(3)	EMISSIONS: OXIDES OF NITROGEN
	GRAMS PER TRIP		
0	9.8	3.1	2.1
10	22.7	3.6	2.3
20	35.4	4.2	2.5
30	48.3	4.8	2.6
40	61.1	5.4	2.8
50	73.9	6.0	2.9
60	87.0	6.6	3.1
70	99.0	7.2	3.2
80	112.	7.8	3.4
90	124.	8.3	3.5
100	137.	8.9	3.7

C. OTHER EMISSIONS

1.	HOT SOAK EMISSIONS (HC)	: 6.0 G/AUTO TRIP
2.	DIURNAL EVAPORATIVE EMISSIONS (HC)	: 9.3 G/AUTO/DAY
3.	DIURNAL EVAPORATIVE EMISSIONS (HC)	: 14.0 G/TRUCK/DAY

(4) ------------64 PERCENT COLD STARTS----------------------

TABLE 4-8(C)

POLLUTANT EMISSION FACTOR COMPONENTS (1) (1987)

A. EMISSIONS FROM HOT STABILIZED OPERATION FREEWAYS AND SURFACE ARTERIALS

SPEED (MPH)	AUTOS CARBON MONOXIDE	AUTOS HYDRO-CARBONS(3)	AUTOS OXIDES OF NITROGEN	TRUCKS (2) CARBON MONOXIDE	TRUCKS (2) HYDRO-CARBONS(3)	TRUCKS (2) OXIDES OF NITROGEN
	(GRAMS PER MILE)			(GRAMS PER MILE)		
60.0	3.55	0.25	2.51	39.21	1.54	10.16
55.0	5.54	0.35	2.21	40.33	1.70	8.41
50.0	6.09	0.39	2.05	40.46	1.81	7.33
45.0	6.11	0.40	1.96	40.93	1.94	6.65
40.0	6.39	0.44	1.90	42.73	2.18	6.19
35.0	7.25	0.50	1.83	46.35	2.57	5.87
30.0	8.72	0.60	1.73	52.02	3.15	5.64
25.0	10.67	0.74	1.60	59.99	3.97	5.49
20.0	12.89	0.90	1.44	70.90	5.15	5.45
15.0	15.73	1.13	1.28	87.05	7.04	5.61

B. EMISSIONS FROM AUTO STARTS

PERCENT OF TRIPS STARTING COLD(4)	EMISSIONS CARBON MONOXIDE	EMISSIONS HYDRO-CARBONS(3)	EMISSIONS OXIDES OF NITROGEN
	GRAMS PER TRIP		
0	9.7	3.3	1.2
10	19.2	3.6	1.4
20	28.7	4.1	1.6
30	38.2	4.4	1.8
40	47.6	4.8	2.0
50	57.1	5.2	2.1
60	66.5	5.6	2.3
70	76.4	6.0	2.5
80	85.4	6.4	2.7
90	95.4	6.8	2.9
100	105.0	7.2	3.1

C. OTHER EMISSIONS

1.	HOT SOAK EMISSIONS (HC)	:	2.2 G/AUTO TRIP
2.	DIURNAL EVAPORATIVE EMISSIONS (HC)	:	3.1 G/AUTO/DAY
3.	DIURNAL EVAPORATIVE EMISSIONS (HC)	:	7.5 G/TRUCK/DAY

(4) ------------67 PERCENT COLD STARTS----------------------

TABLE 4-8(D)

POLLUTANT EMISSION FACTOR COMPONENTS (1) (1995)

A. EMISSIONS FROM HOT STABILIZED OPERATION
FREEWAYS AND SURFACE ARTERIALS

	AUTOS			TRUCKS (2)		
SPEED (MPH)	CARBON MONOXIDE	HYDRO-CARBONS(3)	OXIDES OF NITROGEN	CARBON MONOXIDE	HYDRO-CARBONS(3)	OXIDES OF NITROGEN
	(GRAMS PER MILE)			(GRAMS PER MILE)		
60.0	2.01	0.16	2.38	26.48	0.75	6.52
55.0	3.30	0.23	2.09	27.56	0.88	5.56
50.0	3.64	0.26	1.93	27.82	0.97	4.96
45.0	3.62	0.27	1.85	28.14	1.09	4.58
40.0	3.75	0.29	1.80	29.24	1.28	4.31
35.0	4.24	0.34	1.73	31.44	1.59	4.09
30.0	5.11	0.41	1.63	34.88	2.06	3.91
25.0	6.26	0.50	1.50	39.64	2.75	3.75
20.0	7.52	0.61	1.35	45.91	3.72	3.64
15.0	9.02	0.77	1.20	54.74	5.16	3.63

B. EMISSIONS FROM AUTO STARTS

PERCENT OF TRIPS STARTING COLD(4)	EMISSIONS CARBON MONOXIDE	HYDRO-CARBONS(3)	OXIDES OF NITROGEN
	GRAMS PER TRIP		
0	11.1	3.7	1.2
10	20.4	4.0	1.4
20	29.7	4.4	1.6
30	39.0	4.8	1.8
40	48.3	5.1	2.0
50	57.6	5.5	2.2
60	66.9	5.9	2.4
70	76.2	6.2	2.7
80	85.5	6.6	2.9
90	94.8	7.0	3.1
100	104.0	7.3	3.3

C. OTHER EMISSIONS

1. HOT SOAK EMISSIONS (HC) : 1.1 G/AUTO TRIP
2. DIURNAL EVAPORATIVE EMISSIONS (HC) : 1.1 G/AUTO/DAY
3. DIURNAL EVAPORATIVE EMISSIONS (HC) : 2.2 G/TRUCK/DAY

(4) ------------68 PERCENT COLD STARTS---------------------

TABLE 4-9

EXPRESSWAY AND FREEWAY LAND COSTS
(MILLION $ PER LANE MILE)

		POPULATION GROUPS (1000'S)					
FACILITY TYPE	LOCATION	0-50	50-100	100-250	250-500	500-1000	OVER 1000
NEW ROADS(1)	CBD	0.47	0.47	0.56	0.71	0.94	1.45
	FRINGE	0.47	0.47	0.51	0.56	0.54	0.94
	RESIDENTIAL	0.42	0.42	0.47	0.47	0.60	0.84
RECONSTRUCTION(2)	CBD	0.47	0.47	0.56	0.67	0.90	1.36
	FRINGE	0.25	0.25	0.28	0.30	0.37	0.47
	RESIDENTIAL	0.21	0.21	0.22	0.25	0.26	0.34
MAJOR WIDENING(2)	CBD	0.37	0.37	0.39	0.45	0.51	0.67
	FRINGE	0.18	0.18	0.22	0.26	0.31	0.45
	RESIDENTIAL	0.05	0.05	0.79	0.12	0.21	0.39

NOTE: 1976 COST DATA.

(1) THIS ASSUMES THAT NO LAND HAS BEEN PURCHASED BEFOREHAND.

(2) THIS ASSUMES OWNERSHIP OF MOST LAND NEEDED.

NOTE: THE ABOVE DATA REFLECT A PER LANE COST.

SOURCE: BHATT, K., AND OLSSON, M., CAPACITY AND COST INPUTS FOR COMMUNITY AGGREGATE PLANNING MODEL (CAPM), WORKING PAPER 5002-3, THE URBAN INSTITUTE, WASHINGTON, D.C., DECEMBER, 1973

SKINNER, L., COSTING URBAN TRANSPORATION ALTERNATIVES, U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, WASHINGTON, D.C.

TABLE 4-10

ARTERIAL LAND COSTS
(MILLION $ PER LANE MILE)

FACILITY TYPE	LOCATION	POPULATION GROUP (1000'S) 0-50	50-100	100-250	250-500	500-1000	OVER 1000
NEW ROADS(1)	CBD	0.42	0.42	0.47	0.54	0.68	0.98
	FRINGE	0.38	0.38	0.41	0.43	0.51	0.64
	RESIDENTIAL	0.22	0.22	0.24	0.25	0.28	0.35
RECONSTRUCTION(2)	CBD	0.14	0.14	0.14	0.17	0.18	0.25
	FRINGE	0.12	0.12	0.12	0.13	0.14	0.18
	RESIDENTIAL	0.09	0.09	0.09	1.12	0.13	0.14
MAJOR WIDENING(2)	CBD	0.21	0.21	0.25	0.30	0.43	0.71
	FRINGE	0.21	0.21	0.25	0.29	0.31	0.42
	RESIDENTIAL	0.12	0.12	0.13	0.14	0.21	0.34

NOTE: 1976 COST DATA.

(1) THIS ASSUMES THAT NO LAND HAS BEEN PURCHASED BEFOREHAND.

(2) THIS ASSUMES OWNERSHIP OF MOST LAND NEEDED.

NOTE: THE ABOVE DATA REFLECT A PER LANE COST.

SOURCE: BHATT, K., AND OLSSON, M., CAPACITY AND COST INPUTS FOR COMMUNITY AGGREGATE PLANNING MODEL (CAPM), WORKING PAPER 5002-3, THE URBAN INSTITUTE, WASHINGTON, D.C., DECEMBER, 1973

SKINNER, L., COSTING URBAN TRANSPORATION ALTERNATIVES, U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, WASHINGTON, D.C.

TABLE 4-11

EXPRESSWAY AND FREEWAY CONSTRUCTION COSTS
(MILLION $ PER LANE MILE)

FACILITY TYPE	LOCATION	POPULATION GROUP (1000'S) 0-50	50-100	100-250	250-500	500-1000	OVER 1000
NEW ROAD	CBD	1.36	1.36	1.40	1.44	1.49	1.62
	FRINGE	0.93	0.93	0.98	1.06	1.23	1.57
	RESIDENTIAL	0.81	0.81	0.81	0.85	0.93	1.10
RECONSTRUCTION(1)	CBD	1.47	1.47	1.48	1.49	1.55	1.65
	FRINGE	0.81	0.81	0.84	0.85	0.89	0.93
	RESIDENTIAL	0.67	0.67	0.68	0.72	0.79	0.89
MAJOR WIDENING	CBD	1.41	1.41	1.44	1.57	1.66	1.94
	FRINGE	1.02	1.02	1.06	1.15	1.36	1.74
	RESIDENTIAL	0.81	0.81	0.85	0.92	1.04	1.28

NOTE: 1976 COST DATA.

(1) COSTS OF PERIODIC RESURFACING ARE INCLUDED IN THESE FIGURES.

NOTE: THE ABOVE DATA REFLECT A PER LANE COST.

COSTS ARE NOT BROKEN DOWN BY DESIGN TYPE (E.G., AT GRADE, ELEVATED, ETC.) BUT REFLECT THE AVERAGE OF THESE BY POPULATION GROUP.

SOURCE: BHATT, K., AND OLSSON, M., <u>CAPACITY AND COST INPUTS FOR COMMUNITY AGGREGATE PLANNING MODEL (CAPM)</u>, WORKING PAPER 5002-3, THE URBAN INSTITUTE, WASHINGTON, D.C., DECEMBER, 1973

SKINNER, L., <u>COSTING URBAN TRANSPORATION ALTERNATIVES</u>, U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, WASHINGTON, D.C.

TABLE 4-12

ARTERIAL CONSTRUCTION COSTS
(MILLION $ PER LANE MILE)

FACILITY TYPE	LOCATION	POPULATION GROUPS (1000'S) 0-50	50-100	100-250	250-500	500-1000	OVER 1000
NEW ROADS	CBD	0.43	0.43	0.47	0.51	0.60	0.73
	FRINGE	0.38	0.38	0.39	0.43	0.47	0.60
	RESIDENTIAL	0.34	0.34	0.35	0.38	0.43	0.50
RECONSTRUCTION(1)	CBD	0.43	0.43	0.46	0.47	0.52	0.64
	FRINGE	0.39	0.39	0.41	0.43	0.46	0.51
	RESIDENTIAL	0.37	0.37	0.38	0.38	0.41	0.43
MAJOR WIDENING	CBD	0.43	0.43	0.47	0.51	0.55	0.72
	FRINGE	0.41	0.41	0.43	0.45	0.51	0.59
	RESIDENTIAL	0.41	0.41	0.43	0 45	0.51	0.59

(1) COSTS OF PERIODIC RESURFACING ARE INCLUDED IN THESE FIGURES.

NOTE: COSTS PROJECTED FROM A 1973 BASE TO A 1976 LEVEL USING THE FHWA FEDERAL AID HIGHWAY CONSTRUCTION INDEX.

THE ABOVE DATA REFLECT A PER LANE COST.

COSTS ARE NOT BROKEN DOWN BY DESIGN TYPE (E.G., AT GRADE, ELEVATED, ETC.) BUT REFLECT THE AVERAGE OF THESE BY POPULATION GROUP.

SOURCE: BHATT, K., AND OLSSON, M., _CAPACITY AND COST INPUTS FOR COMMUNITY AGGREGATE PLANNING MODEL (CAPM)_, WORKING PAPER 5002-3, THE URBAN INSTITUTE, WASHINGTON, D.C., DECEMBER, 1973

TABLE 4-13
ANNUAL COST OF MAINTENANCE
($ PER LANE MILE)

FACILITY TYPE	TYPE OF MAINTENANCE		TOTAL
	GENERAL	LIGHTING	
EXPRESSWAYS	$2860	$2490	$5350
ARTERIALS	$1470	$ 580	$2050
RESIDENTIAL AND CBD STREETS	$1100	$1050	$2150

NOTE: DATA EXPRESSED IN TERMS OF 1976 COSTS. THESE FIGURES DO NOT INCLUDE PERIODIC RESURFACING COSTS. PERIODIC RESURFACING IS INCLUDED IN REHABILITATION COSTS OF TABLES 4-12 AND 4-13.

SOURCE; BHATT, K., AND OLSSON, M., "ANALYSIS OF SUPPLY AND ESTIMATES OF REVENUE COSTS," TECHNICAL REPORT 2, THE URBAN INSTITUTE, WASHINGTON, D.C., NOVEMBER, 1973

SKINNER, L., COSTING URBAN TRANSPORATION ALTERNATIVES, U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, WASHINGTON, D.C.

TABLE 4-14

SURFACE PARKING COSTS

LAND COST PER SQ FT	LAND AND CONSTRUCTION COST(1) PER STALL	ANNUAL OPERATING COST(2) PER STALL
$15	$5,380	$325
12	4,380	290
10	3,720	265
8	3,060	240
5	2,080	205
2	1,080	165
1	760	155

(1) COSTS INCLUDE IMPROVEMENT COSTS AND PRORATED LAND COSTS BASED ON A 330 SQUARE FOOT STALL.
(2) INCLUDES PROPERTY TAXES.

NOTE: DATA PROJECTED FROM 1970 BASE TO 1976, USING ENR CONSTRUCTION INDEX FOR CONSTRUCTION EXPENDITURE AND USING CONSUMER PRICE INDEX FOR OPERATING COSTS.

SOURCES: PARKING STANDARDS REPORT, PARKING STANDARDS DESIGN ASSOCIATES, LOS ANGELES, 1971

TABLE 4-15

UNDERGROUND STRUCTURE PARKING COSTS(1)

PARKING METHOD	CONSTRUCTION COST PER STALL	ANNUAL OPERATING COSTS PER STALL
SELF PARK - SINGLE DEPTH(2)	$7,320	$305
SELF PARK - TANDEM	6,100	280
ATTENDANT ASSIST - TANDEM	6,100	315
ATTENDANT PARK - TANDEM	6,100	360

(1) COSTS INCLUDE CONSTRUCTION COSTS, BASED ON 330 SQUARE FOOT STALL.
(2) SINGLE DEPTH STALL IS 360 SQUARE FEET.

NOTE: COSTS UPDATED TO 1976 FROM 1970 BASE, USING THE ENR CONSTRUCTION INDEX FOR CONSTRUCTION EXPENDITURES AND THE CONSUMER PRICE INDEX FOR OPERATING COSTS.

SOURCE: PARKING STANDARDS REPORT, PARKING STANDARDS DESIGN ASSOCIATES, LOS ANGELES, 1971

TABLE 4-16

MULTI-LEVEL STRUCTURE PARKING COSTS

LAND COST PER SQ FT	TOTAL COST PER STALL(1) NUMBER OF LEVELS 3	5	7	9	ANNUAL OPERATING(2) COST PER STALL
$150	$18,150	$12,050	$9,720	$8,650	$505
125	15,400	10,400	8,540	7,730	460
100	12,650	8,750	7,360	6,820	410
80	10,450	7,430	6,420	6,080	375
60	8,250	6,110	5,480	5,350	335
40	6,050	4,790	4,535	4,620	295
20	3,850	3,470	3,590	3,880	260
10	2,750	2,810	3,120	3,520	240
5	2,200	2,480	2,890	3,330	230
2	1,870	2,280	2,740	3,220	225

(1) COSTS INCLUDE CONSTRUCTION AND PRORATED LAND COSTS BASED ON A 330 SQUARE FOOT STALL.
(2) INCLUDES PROPERTY TAXES.

NOTE: DATA PROJECTED FROM 1970 BASE TO 1976, USING ENR CONSTRUCTION INDEX FOR CONSTRUCTION EXPENDITURES AND USING CONSUMER PRICE INDEX FOR OPERATING COSTS.

SOURCE: PARKING STANDARDS REPORT, PARKING STANDARDS DESIGN ASSOCIATES, LOS ANGELES, 1971

TABLE 4-17

URBAN ACCIDENT FREQUENCY ON SURFACE STREETS
PER MILLION VEHICLE MILES
(1967-1970)

	FREQUENCY OF VEHICLE ACCIDENTS (FREQUENCY OF PERSON ACCIDENTS)			
FACILITY	PROPERTY DAMAGE(1)	INJURY	FATALITY	TOTAL
FREEWAY	4.028	.642(1.025)	.016(0.019)	4.686(1.044)
ARTERIAL	16.523	1.644(2.650)	.029(0.032)	18.196(2.682)
LOCAL	16.523(2)	2.477(3.646)	.028(0.030)	19.028(3.676)

(1) THE NUMBER OF PROPERTY DAMAGE ACCIDENTS WAS MULTIPLIED BY 2.94 TO ACCOUNT FOR UNREPORTED ACCIDENTS; PERSON ACCIDENTS ARE NOT INCLUDED IN THIS CATEGORY.
(2) LACKING DATA FOR LOCAL STREETS, IT HAS BEEN ASSUMED THAT LOCAL AND ARTERIALS HAVE THE SAME PROPERTY DAMAGE RATE.

NOTE: NUMBERS IN PARENTHESES ARE THE NUMBERS OF PERSONS INVOLVED IN THE PARTICULAR TYPE OF ACCIDENT IN QUESTION; DATA REFLECT NATIONAL AVERAGES FROM 1967-1970 AND INCLUDE A MIXED TRAFFIC STREAM (TRUCKS, BUSES, AUTOMOBILES, ETC.)

SOURCES: FEDERAL HIGHWAY ADMINISTRATION, "FATAL AND INJURY ACCIDENT RATES ON FEDERAL AID AND OTHER HIGHWAY SYSTEMS," U.S. DEPARTMENT OF TRANSPORTATION, 1973.

GENDELL, D.S., "ACCIDENT RATES AND COSTS," TRANS TECHNICAL NOTES, U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION, SEPTEMBER, 1971

TABLE 4-18

COST OF ACCIDENTS

ACCIDENT TYPE	DIRECT COSTS PER ACCIDENT (1976 DOLLARS)			
	AUTOMOBILE		TRUCK	
	URBAN	RURAL	URBAN	RURAL
FATAL	$27,515	$27,703	$24,529	$28,353
NONFATAL INJURY	4,830	5,961	2,593	6,672
PROPERTY DAMAGE	599	731	405	861

NOTE: THESE COSTS REPRESENT DIRECT COSTS ONLY (MEDICAL EXPENSES AND VEHICLE REPAIR) DERIVED FROM AN ANALYSIS OF ILLINOIS DATA. DISCOUNTED FOREGONE EARNINGS AND VALUE OF LIFE ARE NOT INCLUDED. COSTS HAVE BEEN CONVERTED FROM AN INVOLVEMENT TO AN ACCIDENT BASE. 1969 BASE FIGURES PROJECTED TO 1976 USING CONSUMER PRICE INDEX.

SOURCE: GENDELL, D.S., "ACCIDENT RATES AND COSTS," TRANS TECHNICAL NOTES, FEDERAL HIGHWAY ADMINISTRATION, SEPTEMBER, 1971

TABLE 4-19

COMPOSITE VEHICLE ACCIDENT COSTS

ACCIDENT TYPE	DIRECT COSTS PER ACCIDENT (1976 DOLLARS)			
	URBAN		RURAL	
	FREEWAY	SURFACE ARTERIAL	FREEWAY	OTHER ARTERIAL
FATAL	$27,213	$27,328	$27,798	$27,785
NONFATAL INJURY	4,602	4,789	6,062	6,050
PROPERTY DAMAGE	580	585	750	747

NOTE: THE COSTS IN THIS TABLE HAVE BEEN DERIVED BY WEIGHTING THE COSTS IN TABLE 4-19 IN PROPORTION TO THE VEHICLES WHICH ARE AUTOMOBILES OR TRUCKS BY FACILITY AND AREA TYPE.

SOURCE: GENDELL, D. S., "ACCIDENT RATES AND COSTS," TRANS TECHNICAL NOTES, FEDERAL HIGHWAY ADMINISTRATION, SEPTEMBER, 1971

TABLE 4-20

TYPES OF MOTOR VEHICLES INVOLVED IN ACCIDENTS
(1974)

TYPE TYPE	FATAL ACCIDENTS (PERCENT)	ALL ACCIDENTS (PERCENT)	PERCENT OF REGISTRATION (PERCENT)
PASSENGER CAR	71.3	82.7	77.7
TRUCK	20.1	13.7	18.4
TAXICAB	0.4	0.6	0.2
MOTORCYCLE	5.7	1.5	3.7
OTHER	2.5	1.5	DATA NOT AVAILABLE

SOURCE: NATIONAL SAFETY COUNCIL, "ACCIDENT FACTS," 1975 EDITION

CHAPTER V

ACTIVITY CENTER SYSTEMS

THIS CHAPTER CONTAINS A SET OF VALUES FOR PARAMETERS THAT CHARACTERIZE ACTIVITY CENTER SYSTEMS. ACTIVITY CENTER SYSTEMS ARE A NEW CLASS OF TRANSPORTATION SYSTEM. BECAUSE OF THE RAPIDLY CHANGING STATE OF THE ART FOR THESE SYSTEMS, AND THE RELATIVE RARENESS OF INSTALLATIONS, TWO POINTS MUST BE MADE. THE DATA ARE LIMITED, AND THOSE PRESENTED MUST BE USED WITH CARE. DATA ARE PRESENTED ONLY FOR SYSTEMS WHICH ARE ACTUALLY IN USE, UNDER CONSTRUCTION, OR FOR WHICH FIRM QUOTES FOR CONSTRUCTION HAVE BEEN SUBMITTED. THE SET OF ACTIVITY SYSTEMS CENTERS INCLUDED HERE IS NOT EXHAUSTIVE, BUT REPRESENTS THOSE NOW AVAILABLE FOR INSTALLATION.

TABLE 5-1

ACTIVITY CENTER SYSTEMS - VEHICLE CAPACITIES(1)

	VEHICLE CAPACITY-PERSONS (RANGE 4-102)			VEHICLE CAPACITY-PERSONS (RANGE 4-400)	
	SEATED	STANDING	TOTAL CRUSH CAPACITY	MAX. NUMBER OF VEHICLES IN TRAIN	CRUSH TRAIN CAPACITY
AIRTRANS	16	24	60	2	120
ACT	10	14	30	1	30
DASHAVEYOR I	40	20	60	4	240
DASHAVEYOR II	45	55	100	4	400
MORGANTOWN	8	7	21	1	21
SKYBUS - TAMPA	0	100	100	1	100
SKYBUS - SEATAC	12	90	102	2	204
JETRAIL	6	9	15	1	15
CARVEYOR	6	6	12	1	12
ROHR P	6	6	14	3 (THE STANDARD UNIT)	42
ROHR N	75	0	75	2	150
ROHR M(2)	26	28	54	4	216

(1) REFER TO APPENDIX E FOR A DETAILED DESCRIPTION OF EACH SYSTEM.

NOTE: TABLE 5-2 TOGETHER WITH THIS TABLE WILL ENABLE A ROUGH CALCULATION TO BE MADE OF THE THEORETICAL MAXIMUM LINE CAPACITY FOR A SYSTEM:

$$\text{MAX CAPACITY} = \frac{\text{(MAX TRAIN CAPACITY)}}{\text{(MIN HEADWAY)}}$$

TABLE 5-3 GIVES THE REPORTED CAPACITY FOR EACH OF THE SYSTEMS.

THE NUMBER OF VEHICLES NEEDED TO HANDLE THE CAPACITY WILL BE A FUNCTION OF AVERAGE SPEED, LENGTH OF ROUTE, DWELL TIME, AND VEHICLE MAINTENANCE REQUIREMENTS. IT IS CALCULATED AS:

$$\text{REQUIRED VEHICLES} = \frac{\text{(REQUIRED CAPACITY PER HOUR)}}{\text{(TRAIN CAPACITY X AVERAGE SPEED)}} \times$$

(NUMBER OF VEHICLES PER TRAIN) X (LENGTH OF ROUTE) X

(MAINTENANCE FACTOR)

THE MAINTENANCE FACTOR IS THAT PROPORTION BY WHICH THE FLEET MUST BE INCREASED TO ALLOW FOR REGULARLY SCHEDULED MAINTENANCE. IN THIS FORMULA THE AUGMENTATION OF THE FLEET BY 5% TO ACCOUNT FOR THIS WOULD YIELD A MAINTENANCE FACTOR OF 1.05.

SOURCES: DE LEUW, CATHER & COMPANY ET AL, AUTOMATED SMALL VEHICLE FIXED GUIDEWAY SYSTEMS STUDY, TWIN CITIES METROPOLITAN TRANSIT COMMISSION, 1975

CASEY, ROBERT, SUMMARY DATA FOR SELECTED NEW URBAN TRANSPORTATION SYSTEMS, DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., NOVEMBER, 1972

LEA TRANSIT COMPENDIUM, N.D. LEA TRANSPORTATION RESEARCH CORPORATION, 1974

TABLE 5-2

ACTIVITY CENTER SYSTEMS - SPEEDS, HEADWAYS, AND DWELL TIMES(1)

SPEED RANGE	12-50 MPH
HEADWAY RANGE	5-105 SEC
DWELL TIME RANGE	15-45 SEC

SYSTEM	CRUISE SPEED(2) MPH	MIN. HEADWAY SEC	MIN. DWELL TIME SEC
AIRTRANS	17	18	30
ACT	30	5	20
DASHAVEYOR I	30	15	15-20
DASHAVEYOR II	50	15	15-20
MORGANTOWN	30	15	15
SKYBUS - TAMPA	30	70	30
SKYBUS - SEATAC	30	105	45
JETRAIL	15	18	20
CARVEYOR	15	4.5	18-28
ROHR P	12	60	N.A.
ROHR M/N	30	60	30

(1) REFER TO APPENDIX E FOR A DETAILED DESCRIPTION OF EACH SYSTEM.
(2) CRUISE SPEED IS THE SPEED AT WHICH THE VEHICLE NORMALLY OPERATES WITH NO ACCELERATION OR DECELERATION. AVERAGE SPEED WILL BE DETERMINED BY STATION SPACING, ACCELERATION RATES, AND SUCH FACTORS AS SWITCHING SPEED (THIS MAY BE QUITE LOW; E.G., AIRTRANS=8 MPH, DASHAVEYOR=7.5 MPH).

NOTE: THESE ARE REPORTED VALUES AND SHOULD BE TREATED WITH CAUTIOUS SKEPTICISM.

SOURCES: DE LEUW, CATHER & COMPANY ET AL, AUTOMATED SMALL VEHICLE FIXED GUIDEWAY SYSTEMS STUDY, TWIN CITIES AREA METROPOLITAN TRANSIT COMMISSION, 1975

CASEY, ROBERT, SUMMARY DATA FOR SELECTED NEW URBAN TRANSPORTATION SYSTEMS, DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., NOVEMBER, 1972

LEA TRANSIT COMPENDIUM, N.D. LEA TRANSPORTATION RESEARCH CORPORATION, 1974

TABLE 5-3

ACTIVITY CENTER SYSTEMS - CAPACITIES(1)

RANGE OF INSTALLED SYSTEMS - 800-9,000 PASSENGERS/HR
RANGE OF THEORETICAL SYSTEMS - 2,000-96,000 PASSENGERS/HR

SYSTEM	REPORTED/INSTALLED(2) CAPACITY (PASSENGER/HR)	THEORETICAL MAXIMUM(3) LINE CAPACITY (PASSENGER/HR)
AIR TRANS	9,000	24,000
ACT(4)	800	21,600
DASHAVEYOR I(4)	7,200	57,600
DASHAVEYOR II	N.A.	96,000
MORGANTOWN	5,040	5,040
SKYBUS - TAMPA	5,040	5,150
SKYBUS - SEATAC	4,800	7,000
JETRAIL	2,000	3,000
CARVEYOR	N.A.	9,600
ROHR P	2,160	2,520
ROHR N(4)	7,800	9,000
ROHR M	N.A.	13,000

(1) REFER TO APPENDIX E FOR A DETAILED DESCRIPTION OF EACH SYSTEM.

(2) REPORTED/INSTALLED CAPACITIES ARE FLOWS REALIZED GIVEN THE PARTICULAR CONFIGURATION OF THE SYSTEM IN TERMS OF STATION SPACING, ACCESS/EGRESS, ETC.

(3) CALCULATED USING VALUES IN TABLES 5-1 AND 5-2 AND FORMULA

$$\text{MAX CAPACITY} = \frac{\text{(MAX TRAIN CAPACITY)}}{\text{(MIN HEADWAY (IN HOURS))}}$$

(4) VALUES WERE CALCULATED FROM INSTALLATION DATA.

SOURCES: DE LEUW, CATHER & COMPANY ET AL, AUTOMATED SMALL VEHICLE FIXED GUIDEWAY SYSTEMS STUDY, TWIN CITIES AREA METROPOLITAN TRANSIT COMMISSION, 1975

CASEY, ROBERT, SUMMARY DATA FOR SELECTED NEW URBAN TRANSPORTATION SYSTEMS, DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., NOVEMBER, 1972

LEA TRANSIT COMPENDIUM, N.D. LEA TRANSPORTATION RESEARCH CORPORATION, 1974

TABLE 5-4

ACTIVITY CENTER SYSTEMS CAPITAL COSTS(1)

RANGE ($ MILL/MILE)
.8 - 11.0

NAME OF SYSTEM	YEAR	COST PER LANE MILE(2) ($ MILL/MILE)	SIZE OF INSTALLATION (MILES)
AIRTRANS	1972	2.7	13
SKYBUS - TAMPA	1968	4.1	1.35
SKYBUS - SEATAC	1969	3.1	1.71
JETRAIL(3)	--	1.2	1.4
MORGANTOWN	1973	11.0	5.5
DASHAVEYOR	1973	4.0	3
ACT - FAIRLANE	1974	4.0	1
ACT - BRADLEY	1973	6.8	.69
ACT - EL PASO	1974	9.3	1.5
ROHR M-N SERIES(3)	1972	1.0	1
ROHR P SERIES(3)	1971	.8	1
CARVEYOR (SEATAC QUOTE)	1968	2.8	1.71
CARVEYOR (TAMPA QUOTE)	1969	3.4	1.35

(1) REFER TO APPENDIX E FOR DETAILED DESCRIPTION OF EACH INSTALLATION.

(2) THESE COSTS HAVE BEEN BASED ON SINGLE LANE GUIDEWAY. WHERE DOUBLE GUIDEWAY COSTS WERE QUOTED, THEY WERE DIVIDED BY TWO TO DERIVE A SINGLE GUIDEWAY COST. THE ONLY DOUBLE GUIDEWAY COSTS TREATED IN THE ABOVE TABLE WERE FOR THE CARVEYOR SYSTEMS.

(3) BASED ON UNIT PRICES.

NOTE: COSTS INCLUDE VEHICLES, TERMINALS, GUIDEWAY, COMMUNICATIONS AND CONTROL, MAINTENANCE SHOP, AND STORAGE YARDS; DO NOT INCLUDE ROW ACQUISITION, SITE CLEARING, DIFFICULT CONSTRUCTION PROBLEMS, OR OPERATING COSTS.

SOURCES: DE LEUW, CATHER & COMPANY ET AL, AUTOMATED SMALL VEHICLE FIXED GUIDEWAY SYSTEMS STUDY, TWIN CITIES AREA METROPOLITAN TRANSIT COMMISSION, 1975

CASEY, ROBERT, SUMMARY DATA FOR SELECTED NEW URBAN TRANSPORTATION SYSTEMS, DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., NOVEMBER, 1972

LEA TRANSIT COMPENDIUM, N.D. LEA TRANSPORTATION RESEARCH CORPORATION, 1974

SIBLEY, KEITH, MASS TRANSIT TECHNOLOGY: A COMPREHENSIVE SURVEY OF VEHICULAR HARDWARE, RENSSELAER POLYTECHNIC INSTITUTE, TROY, N.Y., 1973

TABLE 5-5

PERCENTAGE CONTRIBUTION TO TOTAL SYSTEM CONSTRUCTION COST

ITEM	AVERAGE CONTRIBUTION %	RANGE %
GUIDEWAY AND ELECTRIFICATION	55	33-78
VEHICLES	16	1-39
STATIONS	14	3-28
YARDS AND SHOPS	5	4-7
COMMUNICATIONS AND CONTROL	10	2-26

SOURCES: DE LEUW, CATHER & COMPANY ET AL, AUTOMATED SMALL VEHICLE FIXED GUIDEWAY SYSTEMS STUDY, TWIN CITIES AREA METROPOLITAN TRANSIT COMMISSION, 1975

CASEY, ROBERT, SUMMARY DATA FOR SELECTED NEW URBAN TRANSPORTATION SYSTEMS, DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., NOVEMBER, 1972

LEA TRANSIT COMPENDIUM, N.D. LEA TRANSPORTATION RESEARCH CORPORATION, 1974

SIBLEY, KEITH, MASS TRANSIT TECHNOLOGY: A COMPREHENSIVE SURVEY OF VEHICULAR HARDWARE, RENSSELAER POLYTECHNIC INSTITUTE, TROY, N.Y., 1973

TABLE 5-6
ACTIVITY CENTER SYSTEMS STATION COSTS

RANGE
$20,000 - $1,000,000

SYSTEM	COST
MORGANTOWN	$400,000-$1,000,000
SKYBUS	$5,000-$100,000
JETRAIL	$20,000
CARVEYOR	$250,000

NOTE: SEE TABLE 5-4 FOR DATE OF COST.

SOURCES: DE LEUW, CATHER & COMPANY ET AL, AUTOMATED SMALL VEHICLE FIXED GUIDEWAY SYSTEMS STUDY, TWIN CITIES AREA METROPOLITAN TRANSIT COMMISSION, 1975

CASEY, ROBERT, SUMMARY DATA FOR SELECTED NEW URBAN TRANSPORTATION SYSTEMS, DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., NOVEMBER, 1972

LEA TRANSIT COMPENDIUM, N.D. LEA TRANSPORTATION RESEARCH CORPORATION, 1974

SIBLEY, KEITH, MASS TRANSIT TECHNOLOGY: A COMPREHENSIVE SURVEY OF VEHICULAR HARDWARE, RENSSELAER POLYTECHNIC INSTITUTE, TROY, N.Y., 1973

TABLE 5-7

ACTIVITY CENTER SYSTEMS VEHICLE COSTS

RANGE $ PER VEHICLE
4,000 - 250,000

SYSTEM	COST PER VEHICLE	COST PER PASSENGER SPACE AT CRUSH CAPACITY
DASHAVEYOR I	$75,000-$125,000	$1,250-$2,090
DASHAVEYOR II	$100,000-$150,000	$1,000-$1,500
MORGANTOWN	$150,000	$7,140
SKYBUS	$250,000	$2,500-$2,800
CARVEYOR	$4,000-$8,000	$333-$667
ROHR M-N	$120,000-$160,000	$1,500-$2,000
ROHR P	$8,400	$600
JETRAIL	$35,000	$2,333

NOTE: REFER TO APPENDIX E FOR DETAILED SYSTEM DESCRIPTION.

SOURCES: DE LEUW, CATHER & COMPANY ET AL, AUTOMATED SMALL VEHICLE FIXED GUIDEWAY SYSTEMS STUDY, TWIN CITIES AREA METROPOLITAN TRANSIT COMMISSION, 1973

CASEY, ROBERT, SUMMARY DATA FOR SELECTED NEW URBAN TRANSPORTATION SYSTEMS, DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., NOVEMBER, 1972

LEA TRANSIT COMPENDIUM, N.D. LEA TRANSPORTATION RESEARCH CORPORATION, 1974

SIBLEY, KEITH, MASS TRANSIT TECHNOLOGY: A COMPREHENSIVE SURVEY OF VEHICULAR HARDWARE, RENSSELAER POLYTECHNIC INSTITUTE, TROY, N.Y., 1973

TABLE 5-8

ACTIVITY CENTER SYSTEMS GUIDEWAY COSTS

RANGE $MILL/PER LANE MILE
.3 MILL - 11.0 MILL

SYSTEM	COST/LANE MILE
ACT	$3 MILL
MORGANTOWN	$11 MILL
JETRAIL	$.4 MILL
DASHAVEYOR	$2 MILL
SKYBUS	$2.6 MILL
CARVEYOR	$2-4 MILL/DOUBLE TRACK
ROHR P	$.3 MILL
ROHR M/N(1)	$.3 MILL

(1) DOES NOT INCLUDE INSTALLATION COST.

NOTE: GUIDEWAY COSTS ONLY ARE PRESENTED HERE. SEE TABLE 5-4 FOR TOTAL SYSTEM COST.

THESE COSTS ARE NOT DIRECTLY COMPARABLE BECAUSE SOME COSTS INCLUDE ELECTRIFICATION AND CONTROL EQUIPMENT WHILE OTHERS DO NOT.

SOURCES: DE LEUW, CATHER & COMPANY ET AL, AUTOMATED SMALL VEHICLE FIXED GUIDEWAY SYSTEMS STUDY, TWIN CITIES AREA METROPOLITAN TRANSIT COMMISSION, 1975

CASEY, ROBERT, SUMMARY DATA FOR SELECTED NEW URBAN TRANSPORTATION SYSTEMS, DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., NOVEMBER, 1972

LEA TRANSIT COMPENDIUM, N.D. LEA TRANSPORTATION RESEARCH CORPORATION, 1974

SIBLEY, KEITH, MASS TRANSIT TECHNOLOGY: A COMPREHENSIVE SURVEY OF VEHICULAR HARDWARE, RENSSELAER POLYTECHNIC INSTITUTE, TROY, N.Y., 1973

CHAPTER VI

PEDESTRIAN ASSISTANCE SYSTEMS

THIS CHAPTER PRESENTS SOME CAPACITY, COST, AND OPERATING CHARACTERISTICS OF PEDESTRIAN ASSISTANCE SYSTEMS. SYSTEMS IN THIS CATEGORY INCLUDE ELEVATORS, ESCALATORS, AND MOVING WALKWAYS.

TABLE 6-1

SPEED OF WALKING

SPEED		PERCENT OF	CUMULATIVE
FEET PER MINUTE	MILES PER HOUR	POPULATION	PERCENT
LESS THAN 120	LESS THAN 1.36	0	0
120-180	1.36-2.05	8	8
180-210	2.05-2.39	11	19
210-240	2.39-2.73	16	35
240-270	2.73-3.07	20	55
270-300	3.07-3.41	20	75
300-330	3.41-3.75	13	88
330-360	3.75-4.09	9	97
360-390	4.09-4.43	3	100

AVERAGE SPEED = 262 FEET/MINUTE OR 2.98 MILES/HOUR

SOURCE: JACKSON AND MORELAND, "THE FEASIBILITY STUDY OF MOVING WALKWAYS," BOSTON REDEVELOPMENT AUTHORITY, JANUARY, 1971

TABLE 6-2

PRACTICAL OPERATING CAPACITY OF STANDARD TURNSTILES

TYPE OF TURNSTILE	CAPACITY (PERSONS PER MINUTE)
REGISTERING:	
FREE ADMISSION	40-60
WITH TICKET COLLECTOR	25-35
CASHIER OPERATED	12-18
COIN OPERATED LOW:	
SINGLE SLOT	25-50
MULTIPLE FARE	15-25
COIN OPERATED (7 FT.) HIGH	10-15
NON-REGISTERING:	
LOW TRAFFIC CONTROLLER	40-60
7 FT. HIGH TRAFFIC CONTROLLER (ROTO-GATE)	25-40

SOURCE: BAERWALD, JOHN, EDITOR, "TRAFFIC ENGINEERING HANDBOOK," INSTITUTE OF TRAFFIC ENGINEERS, WASHINGTON, D.C., 1965

TABLE 6-3

PEDESTRIAN STAIR SPEEDS
HORIZONTAL TIME-MEAN-SPEEDS
(FEET/MINUTE)

AGE GROUP	OUTDOOR STAIRS(1) SPEED UP	OUTDOOR STAIRS(1) SPEED DOWN	OUTDOOR STAIRS(1) STEPS/MINUTE UP	OUTDOOR STAIRS(1) STEPS/MINUTE DOWN	INDOOR STAIRS(2) SPEED UP	INDOOR STAIRS(2) SPEED DOWN	INDOOR STAIRS(2) STEPS/MINUTE UP	INDOOR STAIRS(2) STEPS/MINUTE DOWN
29 AND UNDER	115	160	117	163	108	149	116	160
30-50	114	153	116	160	99	127	106	136
OVER 50	83	117	84	119	83	108	89	116
AVERAGE	113	150	115	153	100	132	107	141

(1) 6" RISER, 12.0" TREAD, 27 DEGREE ANGLE.
(2) 7" RISER, 11.25" TREAD, 32 DEGREE ANGLE.

SOURCE: FRUIN, J.J., PEDESTRIAN PLANNING AND DESIGN, METROPOLITAN ASSOCIATION OF URBAN DESIGNERS AND ENVIRONMENTAL PLANNERS, INC., CHURCHILL, N.Y., 1971

TABLE 6-4

MAXIMUM STAIRWAY CAPACITY
(PPM/FT)(1)

UP	DOWN
18.9	20.0

(1) VALUES IN PEDESTRIANS/MINUTE/FOOT OF STAIR WIDTH.

SOURCE: FRUIN, J.J., DESIGNING FOR PEDESTRIANS - A LEVEL OF SERVICE CONCEPT. A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY, POLYTECHNIC INSTITUTE OF BROOKLYN, BROOKLYN, NEW YORK, 1970

TABLE 6-5

ESCALATOR CAPACITIES AND BOARDING TIMES

	CAPACITY			
INCLINE SPEED(1) (FEET PER MINUTE)	90	120	90	120
WIDTH AT HIP (INCHES)	32	32	48	48
WIDTH AT TREAD (INCHES)	24	24	40	40
MAXIMUM THEORETICAL CAPACITY (PERSONS/HOUR)	5,000	6,700	8,000	10,700
NOMINAL CAPACITY(2) (PERSONS/HOUR)	3,750	5,025	6,000	8,025
NOMINAL CAPACITY (PERSONS/MINUTE)	63	84	100	133

(1) INCLINE SPEED 90 FEET PER MINUTE IS 68 STEPS PER MINUTE.
INCLINE SPEED 120 FEET PER MINUTE IS 89 STEPS PER MINUTE.
(2) NOMINAL CAPACITY IS 75% OF THEORETICAL MAXIMUM CAPACITY.

BOARDING TIME (SECONDS)

LIGHT TRAFFIC		HEAVY TRAFFIC
NO BAGGAGE	BAGGAGE	NO BAGGAGE
.98	1.05	1.17

SOURCE: FRUIN, J.J., PEDESTRIAN PLANNING AND DESIGN, METROPOLITAN ASSOCIATION OF URBAN DESIGNERS AND ENVIRONMENTAL PLANNERS, INC., CHURCHILL, N.Y., 1971

TABLE 6-6

MOVING WALKWAY CAPACITIES(1)

TREADWAY INCLINE SPEED FEET/MINUTE	MAXIMUM CAPACITY PERSONS/ MINUTE (PERSONS/ HOUR)	MAXIMUM CAPACITY PERSONS/ MINUTE PER FOOT OF WIDTH (PERSONS/HOUR PER FOOT OF WIDTH)	NOMINAL CAPACITY(2) PERSONS/ MINUTE (PERSONS/ HOUR)
0 DEGREE INCLINE 180	240 (14,400)	72 (4,320)	180 (10,000)
5 DEGREE INCLINE 140	186 (11,180)	56 (3,354)	140 (8,400)
10 DEGREE INCLINE 130	173 (10,400)	52 (3,120)	130 (7,800)
15 DEGREE INCLINE 125	167 (10,000)	50 (3,000)	125 (7,500)

(1) 40-INCH NOMINAL WIDTH (2 PERSONS PER 1.5 FOOT TREADWAY). SPEED, ANGLES, AND CAPACITIES WILL VARY WITH WIDTH PER ASA 17.1 (CODE) PART XIII.
(2) NOMINAL CAPACITY IS 75% OF THEORETICAL MAXIMUM CAPACITY.

SOURCE: STRAKOSCH, G., VERTICAL TRANSPORTATION, ELEVATORS AND ESCALATORS, OTIS ELEVATOR CO., WILEY, N.Y., 1967

TABLE 6-7

ELEVATOR CAPACITY CONSIDERATIONS

BUILDING TYPE	POPULATION SERVED	DESIRABLE DIRECTIONAL CAPACITY	DESIRABLE FREQUENCY
OFFICE BUILDINGS	1 PERSON PER 120-175 SQ.FT.OF USABLE AREA	(A)DIVERSIFIED TENANTS 11-12.5% POPULATION SERVED PER 5 MIN. (B)SINGLE PURPOSE TENANTS 12.5-18% POPULATION SERVED PER 5 MIN.	30 SECONDS
APARTMENTS	1.5 TO 2 PERSONS PER BEDROOM	5-7% POPULATION SERVED PER 5 MIN.	60-90 SECONDS
MOTELS AND HOTELS	(A)CONVENTION TYPE HOTELS 1.5-1.9 PERSONS PER ROOM AT 85-95% OCCUPANCY (B)MOTELS, LIMITED SERVICE HOTELS, 1.3-1.5 PERSONS PER ROOM AT 60-75% OCCUPANCY	10-12% OF POPULATION SERVED PER 5 MIN.	40-90 SECONDS; TARGET 50 SECONDS
HOSPITALS	(A)PEDESTRIAN TRAFFIC 3.0-3.5 PERSONS PER BED	10-20% OF POPULATION SERVED PER 5 MIN.	40 SECONDS
	(B)EQUIPMENT TRAFFIC 4 VEHICLES PER 100 BEDS	100% OF VEHICLES PER 5 MIN.	50 SECONDS

SOURCE: <u>VERTICAL TRANSPORTATION 1974</u>, OTIS ELEVATOR COMPANY, 1973

TABLE 6-8

ELEVATOR CAPACITIES

BUILDING TYPE	SUGGESTED ELEVATOR CAPACITIES (PERSONS PER CAR)
APARTMENT	8
APARTMENT AND SMALL FACTORY	13-16
APARTMENT AND OFFICE	16
SMALL OFFICE AND FACTORY	20
OFFICE/HOTEL	20
LARGE OFFICE	23-27
STORE	23

NOTE: THE NUMBER OF SHAFTS REQUIRED IS USUALLY CALCULATED IN A COST MINIMIZATION FORMAT GIVEN STANDARDS OF SERVICE TO BE PROVIDED. THE NUMBER OF SHAFTS IS A FUNCTION OF THE KIND OF MOTOR USED (GEARLESS, GEARED, HYDRAULIC), THE PEAK DEMAND TO BE SERVED, THE NUMBER OF FLOORS IN THE BUILDING, AND THE ACCESS TO ELEVATORS (SINGLE DECK, DOUBLE DECK). IN GENERAL TERMS IT IS EXPRESSED AS:

$$\text{SHAFTS} = \frac{\text{(PEAK DEMAND(PERSONS/MIN))} \times \text{(FLOORS IN BUILDING)} \times \text{(FLOOR HEIGHT(FT))}}{\text{(CAR CAPACITY(PERSONS/CAR))} \times \text{(AVERAGE CAR SPEED (FEET PER MINUTE))}} \times \frac{1}{\text{(ACCESS FACTOR)}}$$

THE ACCESS FACTOR ACCOUNTS FOR THE POSSIBILITY OF SIMULTANEOUS LOADING AT DIFFERENT FLOORS. THE AVERAGE CAR SPEED WILL DEPEND ON THE DISTRIBUTION OF DEMAND, THE NUMBER OF STOPS, THE FLOOR HEIGHT, ETC., WHICH WILL VARY FROM FACILITY TO FACILITY. IT IS NOT THE OPERATING SPEED PRESENTED IN TABLE 6-9.

SOURCE: VERTICAL TRANSPORTATION 1974, OTIS ELEVATOR COMPANY, 1973

TABLE 6-9

ELEVATOR SPEEDS

TYPE OF MOTOR	RANGE OF SPEEDS AVAILABLE (FEET PER MINUTE)	COMMENTS
HYDRAULIC	75	MAXIMUM RISE 40 FEET.
HYDRAULIC	125	MAXIMUM RISE 40 FEET.
GEARED	150	(THESE ARE THE STANDARD SPEED RANGES.
GEARED	200	(
GEARED	350	(
GEARLESS	500	SPEEDS ABOVE 400 FPM ARE USED FOR LARGE MULTI-STORY BUILDINGS AND COST $8,000-$12,000 MORE PER UNIT
GEARLESS	600	
GEARLESS	700 UP TO 1600(1)	

(1) SPEEDS ABOVE 700 FPM AND RISES OF 300 FEET REQUIRE SPECIAL EQUIPMENT.

SOURCE: VERTICAL TRANSPORTATION 1974, OTIS ELEVATOR COMPANY, 1973

DISCUSSION WITH WESTINGHOUSE ELEVATOR, WASHINGTON, D.C., 1975

TABLE 6-10

PEDESTRIAN ASSISTS CAPITAL AND MAINTENANCE COSTS

ESCALATOR (1975)

WIDTH INCHES	RISE FEET	CAPITAL COST	MAINTENANCE COST $ PER MONTH
32	13-14	$70,000-$76,000	100-200
48	13-14	$78,000-$81,000	100-200
48	30(1)	$195,000-$260,000	200-400

ELEVATOR (1975)

FOR A STANDARD 10-12 STORY APPLICATION
4 ELEVATOR UNITS, 200-350 FPM

CAPITAL COST/UNIT(2)	MAINTENANCE/UNIT
$70,000-$76,000	$250-$350 PER MONTH

MOVING WALKWAY

WIDTH	CAPITAL COST	MAINTENANCE
26 INCHES	$1000-$1750/LINEAR FT.	$50-$150 PER MONTH
40 INCHES	$1750-$2200/LINEAR FT.	$50-$150 PER MONTH

(1) A TYPICAL SUBWAY APPLICATION, WITH SPECIAL SAFETY FEATURES.

(2) FOR SPEEDS ABOVE 350 FEET PER MINUTE THE COST WOULD BE $9,000-$13,000 MORE. FOR EACH ADDITIONAL FLOOR THE COST WOULD BE $2,000-$3,000.

SOURCE: OTIS ELEVATOR COMPANY, WASHINGTON, D.C., 1977

WESTINGHOUSE ELEVATOR, WASHINGTON, D.C., 1977

APPENDIX A

MISCELLANEOUS SUPPORTING MATERIAL

TABLE A-1

TYPICAL AMORTIZATION PERIODS
FOR SELECTED VEHICLES AND GUIDEWAYS

	AMORTIZATION PERIOD (YEARS)
RAIL RAPID TRANSIT	
TRACK	20-25
STRUCTURES	50-60
CARS	25-30
COMMUTER RAIL	
TRACK (NO FREIGHT SERVICE)	20-25
STRUCTURES	50-60
CARS	40
ENGINES	30
LIGHT RAIL	
TRACK	20-25
STRUCTURES	50-60
CARS	20-30
BUS	
NORMAL COACH	10-15
DIAL-A-BUS (HEAVY)	6
DIAL-A-BUS (LIGHT)	3
AUTOMOBILE	
LARGE	10
MEDIUM	10
SMALL	10
ROADWAYS	
BRIDGES	30
FREEWAY	20
EXPRESSWAY	20

TABLE A-2

COMPOSITE PRICE INDEXES
(1967 BASE)

YEAR	CONSUMER PRICE INDEX	FHWA CONSTRUCTION INDEX	FHWA MAINTENANCE INDEX	ENR CONSTRUCTION INDEX	ENR GENERAL INDEX
1960	88.7	80.1	78.3	83.3	76.9
1961	89.6	80.7	79.8	84.6	79.1
1962	90.6	83.8	82.1	86.3	81.4
1963	91.7	86.4	84.3	88.5	84.1
1964	92.9	86.9	86.3	91.1	87.4
1965	94.5	90.3	89.7	93.3	90.8
1966	97.2	96.1	97.8	97.2	95.4
1967	100.0	100.0	100.0	100.0	100.0
1968	104.2	103.4	102.8	107.4	107.8
1969	109.8	111.8	110.4	117.7	118.7
1970	116.3	125.6	116.8	124.4	128.9
1971	121.3	131.7	122.7	140.5	146.8
1972	125.0	138.2	131.7	155.2	163.0
1973	133.1	152.4	141.8	168.4	176.5
1974	147.7	201.8	158.7	178.3	188.2
1975	161.2	203.8	173.0	193.3	205.9
1976	170.5	199.3	188.1	210.9	223.4

SOURCES: U.S. DEPARTMENT OF LABOR, CHARTBOOK ON PRICES, WAGES, AND PRODUCTIVITY, WASHINGTON, D.C., FEBRUARY, 1977

FEDERAL HIGHWAY ADMINISTRATION, PRICE TRENDS FOR FEDERAL-AID HIGHWAY CONSTRUCTION, U.S. DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., FEBRUARY, 1977

FEDERAL HIGHWAY ADMINISTRATION, "HIGHWAY MAINTENANCE AND OPERATION COST TREND INDEX", U.S. DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., FEBRUARY 10, 1977.

U.S. BUREAU OF THE CENSUS, STATISTICAL ABSTRACT OF THE UNITED STATES: 1963-76. WASHINGTON, D.C., 1976.

TABLE A-3

COST INDEX OF RAILROAD MATERIAL AND WAGE RATES
(1967 BASE)

YEAR	FUEL	MATERIAL AND SUPPLY	WAGES
1964	93.3	94.2	86.3
1965	95.6	94.9	90.9
1966	97.2	96.5	93.9
1967	100.0	100.0	100.0
1968	103.5	102.6	105.1
1969	106.7	105.5	112.2
1970	110.5	109.4	122.7
1971	114.6	113.5	136.8
1972	117.1	118.1	149.5
1973	136.5	122.9	164.4
1974	272.0	142.1	173.4
1975	321.9	190.2	190.8
1976	350.1	203.2	209.3

SOURCE: ASSOCIATION OF AMERICAN RAILROADS, INDICES OF RAILROAD MATERIAL PRICES AND WAGE RATES, ECONOMICS AND FINANCE DEPARTMENT, WASHINGTON, D.C., FEBRUARY, 1977

TABLE A-4

CONSUMER PRICE INDEXES FOR TRANSPORTATION GOODS (1967 BASE)

YEAR	OVERALL PRIVATE TRANSPORT INDEX(1)	AUTO REPAIRS AND MAINTENANCE	NEW AUTOMOBILE PRICE INDEX	GASOLINE PRICE INDEX	LOCAL TRANSIT FARES
1954	80.3	74.8	94.3	82.5	60.9
1955	78.9	76.5	90.9	83.6	63.4
1956	80.1	79.5	98.5	86.5	65.9
1957	84.7	82.4	98.4	90.0	67.9
1958	87.4	83.7	101.5	88.8	72.0
1959	91.1	85.5	105.9	89.9	74.2
1960	90.6	87.2	104.5	92.5	77.1
1961	91.3	89.3	104.5	91.4	80.5
1962	93.0	90.4	104.1	91.9	83.7
1963	93.4	91.6	103.5	91.8	85.6
1964	94.7	92.8	103.2	91.4	87.6
1965	96.3	94.5	100.9	94.9	89.4
1966	97.5	96.2	99.1	97.0	93.4
1967	100.0	100.0	100.0	100.0	100.0
1968	103.0	105.5	102.8	101.4	105.9
1969	106.5	112.2	104.4	104.7	114.4
1970	111.1	120.6	107.6	105.6	134.5
1971	116.6	129.2	112.0	106.3	143.4
1972	117.5	135.1	111.0	107.6	150.1
1973	121.5	142.2	111.1	118.1	150.1
1974	144.6	164.4	123.7	152.3	147.6
1975	157.6	163.2	134.0	157.5	170.3
1976	171.4	194.4	140.4	181.2	175.8

(1) BASED ON NEW AUTO, OLD AUTO, GASOLINE, OIL, TIRES, REPAIRS AND MAINTENANCE, INSURANCE, REGISTRATION, AND PARKING. SEE INDICES.

SOURCES: BUREAU OF LABOR STATISTICS, HANDBOOK OF LABOR STATISTICS, 1974, U.S. DEPARTMENT OF LABOR, WASHINGTON, D.C., 1976

BUREAU OF LABOR STATISTICS, CPI DETAILED REPORT FOR DECEMBER, 1976, WASHINGTON, D.C.

TABLE A-5

LOCAL TRANSIT WAGE RATE INDEXES
INDEXES(1) OF UNION HOURLY WAGE RATES OF
LOCAL-TRANSIT OPERATING EMPLOYEES
(1967 = 100)

DATE	INDEX	DATE	INDEX
1929: MAY 15	22.3	1953: JULY 1	55.3
1930: MAY 15	22.5	1954: JULY 1	58.0
1931: MAY 15	22.5	1955: JULY 1	59.8
1932: MAY 15	22.1	1956: JULY 1	62.1
1933: MAY 15	(2)	1957: JULY 1	64.7
1934: MAY 15	21.5	1958: JULY 1	68.6
1935: MAY 15	22.2	1959: JULY 1	71.2
1936: MAY 15	22.4	1960: JULY 1	73.9
1937: MAY 15	23.5	1961: JULY 1	76.7
1938: JUNE 1	24.2	1962: JULY 1	79.9
1939: JUNE 1	24.4	1963: JULY 1	82.9
1940: JUNE 1	24.6	1964: JULY 1	86.2
1941: JUNE 1	25.6	1965: JULY 1	89.8
1942: JULY 1	27.4	1966: JULY 1	93.7
1943: JULY 1	29.2	1967: JULY 1	100.0
1944: JULY 1	29.4	1968: JULY 1	106.6
1945: JULY 1	29.7	1969: JULY 1	115.0
1946: JULY 1	34.9	1970: JULY 1	125.2
1947: OCT. 1	39.4	1971: JULY 1	135.8
1948: OCT. 1	43.3	1972: JULY 1	144.9
1949: OCT. 1	45.1	1973: JULY 1	155.4
1950: OCT. 1	47.2	1974: JULY 1	173.3
1951: OCT. 1	50.3	1975: JULY 1	192.9
1952: OCT. 1	54.1	1976: JULY 1	205.1

(1) INDEX SERIES DESIGNED FOR TREND PURPOSES. PERIODIC CHANGES IN UNION WAGE RATES ARE BASED ON COMPARABLE QUOTATIONS FOR THE VARIOUS OCCUPATIONS IN CONSECUTIVE PERIODS, WEIGHTED BY NUMBER OF UNION MEMBERS REPORTED AT EACH QUOTATION IN THE CURRENT SURVEY PERIOD.
(2) INFORMATION NOT AVAILABLE.

SOURCE: U.S. DEPARTMENT OF LABOR, UNION WAGES AND HOURS: LOCAL-TRANSIT OPERATING EMPLOYEES, JULY 1, 1975, BULLETIN 1818, WASHINGTON, D.C.

TABLE A-6

LOCAL TRANSIT AVERAGE WAGE RATES, JULY 1, 1976
(AVERAGE HOURLY UNION WAGE RATES OF
LOCAL-TRANSIT OPERATING EMPLOYEES)

CLASSIFICATION	HOURLY(1) AVERAGE	INCREASE FROM JULY 1, 1972	
		CENTS PER HOUR	PERCENT
ALL LOCAL-TRANSIT OPERATING EMPLOYEES	$6.58	33	5.3
OPERATORS OF SURFACE CARS AND BUSES	$6.53	34	5.5
ELEVATED AND SUBWAY OPERATORS	$6.97	29	3.6

(1) WAGE RATES USED IN THE CALCULATION OF THESE AVERAGES REPRESENT THOSE AVAILABLE AND PAYABLE ON JULY 1, 1976, AND DO NOT INCLUDE INCREASES MADE LATER THAT ARE RETROACTIVE TO JULY 1 OR BEFORE.

SOURCE: U.S. DEPARTMENT OF LABOR. UNION WAGES AND HOURS: LOCAL-TRANSIT OPERATING EMPLOYEES, JULY 1, 1976, BULLETIN 40. 1974, WASHINGTON, D.C.

TABLE A-7

HIGHWAY AND STREET CONSTRUCTION HOURLY WAGE RATES

YEAR	HOURLY RATE ($)
1958	2.43
1959	2.55
1960	2.67
1961	2.81
1962	2.88
1963	3.01
1964	3.14
1965	3.27
1966	3.41
1967	3.57
1968	3.90
1969	4.19
1970	4.51
1971	4.91
1972	5.12
1973	5.12
1974	5.84
1975	6.31
1976	6.73

SOURCE: U.S. DEPARTMENT OF LABOR, EMPLOYMENT AND EARNINGS, 1909-76, BULLETIN 1312-9, WASHINGTON, D.C., MARCH 1976

APPENDIX B

RAPID RAIL AND COMMUTER RAIL TRANSIT

TABLE B-1

EXTENT OF RAIL RAPID SYSTEMS
(1974)

LOCATION	ROUTE MILES OF TRACK
LONDON	252.0
NEW YORK	231.73
TOKYO	171.7
PARIS	154.0
MOSCOW	98.0
CHICAGO	89.0
SAN FRANCISCO	75.0
HAMBURG	55.6
W BERLIN	48.8
OSAKA	43.5
STOCKHOLM	42.9
BOSTON	38.6
LENINGRAD	30.2
MADRID	29.9
PHILADELPHIA	29.0
BARCELONA	24.8
TORONTO	23.8
OSLO	21.7
ATHENS	20.2
BUENOS AIRES	19.6
CLEVELAND	19.0
VIENNA	16.6
MONTREAL	16.1
ROME	6.8
GLASCOW	6.6
BUDAPEST	6.3
KYOTO	2.2

SOURCE: JANE'S WORLD RAILWAYS AND RAPID TRANSIT SYSTEMS 1974-1975, ED. BY PAUL GOLDSACK JANE'S YEARBOOKS, 1975

TABLE B-2

TYPICAL EXISTING RAIL RAPID SPEEDS

LOCATION	FACILITY	AVERAGE SPEED (MPH)	AVERAGE STATION SPACING (MILES)
NEW YORK	IND-6TH-8TH AVE. EXPRESS	24.5	1.3
NEW YORK	IRT-LEXINGTON AVE. EXPRESS	19.6	1.0
NEW YORK	IND-8TH AVE. EXPRESS	28.7	1.6
NEW YORK	IRT-7TH AVE. EXPRESS	19.5	0.8
TORONTO	YONGE STREET SUBWAY	17.6	0.5
CHICAGO	CONGRESS STREET EXPRESSWAY	24.5	0.5
CLEVELAND	RAPID TRANSIT LINE	28.0	1.2
CHICAGO	CTA-DAN RYAN LINE	30.00	--
BOSTON	MBTA (RED LINE)	32.0	0.8-1.27 (1)
PHILADELPHIA	PATCO (LINDENWOLD)	39.0	0.19-3.20 (1)
SAN FRANCISCO	BART	47.0	0.35-5.85 (1)

(1) DIFFERENT SECTIONS OF THESE LINES HAVE DIFFERENT AVERAGE STATION SPACING.

SOURCE: INSTITUTE OF TRAFFIC ENGINEERS, "CAPACITY AND LIMITATIONS OF URBAN TRANSPORTATION MODES," WASHINGTON, D.C., 1965

TRANSPORTATION SYSTEMS CENTER, SAFETY AND AUTOMATIC TRAIN CONTROL FOR RAIL RAPID TRANSIT SYSTEMS, U.S. DEPARTMENT OF TRANSPORTATION, JULY, 1974

TABLE B-3

THEORETICAL EQUATIONS FOR DETERMINING AVERAGE RAIL SPEEDS

CASE 1: STATION SPACING SUFFICIENT TO REACH CRUISE SPEED

$$\bar{V} = \frac{3600\bar{S}}{\frac{V}{2A} + \frac{V}{2B} + \frac{3600\bar{S}}{V} + T_D}$$

WHERE:

$$\bar{S} > \frac{V^2}{7200A} + \frac{V^2}{7200B}$$

CASE 2: STATION SPACING NOT SUFFICIENT TO REACH CRUISE SPEED

$$\bar{V} = \frac{3600}{\left(7200(A+B)/SAB\right)^{1/2} + \frac{T_D}{S}}$$

WHERE:

$$S \leq \frac{V^2}{7200A} + \frac{V^2}{7200B}$$

WITH:

A = ACCELERATION RATE (CONSTANT)(MPHPS)

B = DECELERATION RATE (CONSTANT)(MPHPS)

V = CRUISING (MAXIMUM) SPEED (MPH)

S = STATION SPACING (MILES)

T_D = DWELL TIME (SECONDS)

$\bar{V}$ = AVERAGE SPEED (MPH)

TABLE B-4

THEORETICAL EQUATION FOR DETERMINING RAIL TRANSIT CAPACITIES

$$H = T + 2\,(L/A)^{1/2} + R$$

WHERE:

H = TRAIN HEADWAY (SECONDS)

T = DWELL TIME (SECONDS); TYPICAL AVERAGE DWELL TIMES RANGE FROM 10 TO 30 SECONDS FOR NEW RAIL RAPID TRANSIT SYSTEMS

L = LENGTH OF TRAIN (FEET); OFF PEAK TRAIN LENGTHS ARE TYPICALLY 150 FEET; PEAK ARE 750 FEET

A = AVERAGE ACCELERATION OR DECELERATION (FEET PER SECOND); 3 MPH/SEC IS A TYPICAL VALUE

R = EMERGENCY RESPONSE TIME (SECONDS); RANGES FROM 5.0 SECONDS FOR FULLY AUTOMATIC SYSTEMS, TO 10 SECONDS FOR SEMI-AUTOMATIC, TO 20 SECONDS FOR COMMUTER RAILROADS.

SOURCE: LANG, A., AND SOBERMAN, R., URBAN RAIL TRANSIT: ITS ECONOMICS AND TECHNOLOGY, MIT PRESS, CAMBRIDGE, MASSACHUSETTS, 1964

TABLE B-5

SERVICE VOLUME OF TYPICAL RAIL RAPID TRANSIT LINES (PEAK HOUR)

LOCATION-FACILITY	TRAINS PER HOUR	HEADWAY (SECONDS)	CARS PER TRAIN	CARS PER HOUR	SEATING CAPACITY PER CAR	SEATING CAPACITY PER TRAIN	SEATING CAPACITY TOTAL	ACTUAL PASS-ENGER LOADS
NEW YORK-IND-6TH-8TH-AVE. EXPRESS	32	112	10	320	60	600	19,200	61,400
NEW YORK-IRT-LEXINGTON AVE. EXPRESS	31	116	9	279	40	360	11,160	44,510
NEW YORK-IND-8TH AVE. EXPRESS	30	120	10	300	60	600	18,000	62,030
NEW YORK-IRT - 7TH AVE. EXPRESS	24	150	9	216	40	360	8,640	36,770
TORONTO-YONGE ST. SUBWAY	28	128	8	224	62	496	13,888	35,166
CHICAGO CONGRESS ST. EXPRESSWAY	25	144	6	150	49	294	7,350	10,376
CLEVELAND-RAPID TRANSIT LINE	20	180	6	120	53	318	6,360	6,211
PHILADELPHIA PATCO	30	120	6	180	80	480	14,400	36,000
SAN FRANCISCO BART(1)	6	600	10	60	72	720	4,320	12,720
BOSTON MBTA - RED LINE	15	240	4	60	64	256	3,840	14,340
CHICAGO DAN RYAN LINE	30	120	8	240	50	400	12,000	24,000

(1) HEADWAYS TO BE IMPROVED AFTER OPENING OF TRANSBAY TUNNEL.

SOURCE: INSTITUTE OF TRAFFIC ENGINEERS, CAPACITY AND LIMITATIONS OF URBAN TRANSPORTATION MODES, WASHINGTON, D.C., 1965

TRANSPORTATION SYSTEMS CENTER, SAFETY AND AUTOMATIC TRAIN CONTROL FOR RAIL RAPID TRANSIT SYSTEMS, U.S. DEPARTMENT OF TRANSPORTATION, JULY, 1974

TABLE B-6

SERVICE VOLUME OF TYPICAL LIGHT RAIL TRANSIT SYSTEMS (PEAK HOUR)

LOCATION	VEHICLES PER HOUR	HEADWAY(1) (SECONDS)	ACTUAL PASSENGER LOADS	AVERAGE TRIP LENGTH (MILES)
COLOGNE	59	61	9600	3.2
ROTTERDAM	37	97	4600	---
DUSSELDORF	92	39	14000	2.9
FRANKFURT	23	157	8200	2.7
STUTTGART	40	90	1200	3.5
HANOVER	80	45	18000	3.4
GOTHENBURG	88	41	7200	2.7
BIELEFELD	24	150	4300	2.5

(1) ABOVE NUMBERS ARE BASED ON A SINGLE ONE-WAY TRACK; AS SERVICE VOLUME INCREASES, SPECIAL SIGNALS ARE NECESSARY.

SOURCE: VUCHIC, V., LIGHT RAIL TRANSIT SYSTEMS - A DEFINITION AND EVALUATION, U.S. DEPARTMENT OF TRANSPORTATION, OCTOBER, 1972

TABLE B-7

RAIL RAPID TRANSIT SYSTEM OPERATING COSTS
CENTS PER CAR-MILE (PERCENT OF SYSTEM COST)

COST ITEM	NEW YORK	CHICAGO	PHILADELPHIA	PATH	PATCO	AVERAGE
MAINTENANCE OF WAYS AND STRUCTURES	38 (16)	19 (10)	68 (17)	92 (24)	26 (8)	37 (15)
MAINTENANCE OF VEHICLES	31 (13)	35 (19)	54 (14)	40 (10)	26 (8)	31 (13)
POWER	34 (14)	14 (7)	40 (10)	29 (7)	35 (10)	32 (13)
TRANSPORTATION	104 (43)	72 (38)	136 (35)	110 (28)	53 (16)	100 (42)
GENERAL AND ADMINISTRATIVE	33 (14)	49 (26)	92 (24)	117 (31)	193 (58)	40 (17)
TOTAL	239 (100)	188 (100)	390 (100)	388 (100)	333 (100)	240 (100)
CAR MILES (IN THOUSANDS)	305,458	49,343	14,560	10,657	4,193	
ANNUAL PASSENGER MILES (IN THOUSANDS)	1,077,595	---	54,757	38,340	11,120	

NOTE: EXPRESSED IN TERMS OF 1976 COSTS.
NUMBERS IN PARENTHESES ARE PERCENTS OF TOTAL COST BY SPECIFIC CATEGORY.

SOURCE: AMERICAN PUBLIC TRANSIT ASSOCIATION, <u>TRANSIT OPERATING REPORTS</u>, 1976.

TABLE B-8

COMMUTER RAIL OPERATING COSTS
(1973)

RAILROAD(1)	MAINTENANCE WAY	MAINTENANCE EQUIPMENT	TRANSPORTATION	TRAFFIC	OTHER	TOTAL
	COST CATEGORY (DOLLARS PER CAR-MILE, 1973)					
BOSTON AND MAINE	$.25	$.81	$2.31	$.01	$.17	$3.55
CENTRAL OF NEW JERSEY	.16	.30	.95	.01	.13	1.55
CHICAGO, MILWAUKEE, ST. PAUL, AND PACIFIC	.42	.28	2.02	.07	.24	3.03
CHICAGO NORTHWESTERN	.13	.32	1.01	.03	.11	1.59
CHICAGO, ROCK ISLAND, AND PACIFIC	.19	.57	1.40	.05	.28	2.49
ERIE LACKAWANNA	.15	.40	1.20	.01	.18	1.94
ILLINOIS CENTRAL	.46	.59	1.82	.03	.22	3.12
LONG ISLAND	0.41	0.68	1.34	.01	.27	2.71
READING COMPANY	.33	.47	1.46	.05	.16	2.47
SOUTHERN PACIFIC	.76	.75	2.14	.02	--	3.67
AVERAGE (ALL RAILROADS)	$.33	$.52	$1.57	$.03	$.20	$2.65

(1) DATA REFLECT 1973 COSTS.

SOURCE: INTERSTATE COMMERCE COMMISSION, ANNUAL OPERATING REPORTS, WASHINGTON, D.C., 1972

TABLE B-9

LIGHT RAIL TRANSIT OPERATING COSTS
CENTS PER CAR-MILE (PERCENT OF SYSTEM COSTS)

		NEWARK	NEW ORLEANS	SEPTA	SHAKER HEIGHTS	AVERAGE
C O	MAINTENANCE OF WAYS AND STRUCTURES	23 (11)	70 (23)	69 (23)	30 (11)	51 (18)
S	MAINTENANCE OF VEHICLES	20 (9)	32 (10)	56 (19)	41 (15)	42 (15)
T	POWER	23 (11)	10 (3)	43 (15)	24 (9)	30 (10)
I	TRANSPORTATION	101 (45)	107 (35)	78 (27)	117 (41)	97 (34)
T E	GENERAL AND ADMINISTRATIVE	52 (24)	89 (28)	48 (16)	68 (24)	62 (23)
M	TOTAL	219 (100)	308 (100)	294 (100)	280 (100)	282 (100)
	CARS OWNED	30	35	64	57	
	CAR-MILES	576,822	629,059	1,550,000	1,044,480	
	ANNUAL PASSENGERS	2,197,429	4,247,348	5,053,602	3,611,973	

NOTE: 1975 DATA ADJUSTED TO 1976 COSTS.

SOURCE: AMERICAN PUBLIC TRANSIT ASSOCIATION, TRANSIT OPERATING REPORTS, WASHINGTON, D.C., 1976

TABLE B-10

TYPICAL RAPID RAIL TRANSIT LINE CONSTRUCTION COSTS
(MILLIONS OF DOLLARS)

TYPE OF CONSTRUCTION (LOCATION)	APPROXIMATE ROUTE MILES	COST PER(2) ROUTE MILE
TUNNEL		
CHICAGO-CONGRESS-DEARBORN LINES	4.0	34.6
CHICAGO-KENNEDY LINE	1.0	34.4
CUT AND COVER		
NEW YORK-63RD STREET LINE	6.0	64.2
NEW YORK-2ND AVENUE LINE	6.0	64.3
-2ND AVENUE LINE	3.6	71.4
AT GRADE		
CHICAGO-EISENHOWER LINE	9.0	7.5
CHICAGO-DAN RYAN LINE	9.5	7.0
CHICAGO-KENNEDY LINE	4.2	7.0
STATION(1)		
CENTRAL AREAS	---	12.1
FRINGE AREAS	---	2.6

(1) ASSUMES STATION LENGTHS OF ABOUT 800 FEET.
(2) INCLUDES ALL LINE COSTS SUCH AS SIGNALLING, COMMUNICATIONS, LIGHTING, POWER, AND STATION COSTS (EXCEPT WHERE ISOLATED IN ABOVE TABLE).

NOTE: ABOVE DATA EXPRESSED IN TERMS OF 1976 PRICES.

LOW TUNNELLING COSTS COMPARED WITH CUT AND COVER OCCUR BECAUSE THE FORMER ARE CONSTRUCTED ONLY IN CERTAIN SOIL/ ROCK FORMATIONS.

SOURCES: BHATT, K., AND OLSSON, M., "ANALYSIS OF SUPPLY AND ESTIMATES OF RESOURCE COSTS," URBAN INSTITUTE, TECHNICAL REPORT NO. 2, WASHINGTON, D.C., NOVEMBER, 1973

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY, WASHINGTON, D.C., 1973

TABLE B-11

COST AND CHARACTERISTICS OF
RAIL RAPID TRANSIT ROLLING STOCK

PART I. IDENTIFICATION INFORMATION

DATE ORDERED	DELIVERY DATE	BUILDER	ORDERED BY	REFERENCE
1950		ST. LOUIS	BOSTON METROPOLITAN TRANSIT AUTHORITY	1
1950-51		ST. LOUIS	CHICAGO TRANSIT AUTHORITY	2
1952		GLOUCESTER RY. CARRIAGE & WAGON CO.	TORONTO TRANSIT COMMISSION	3
1952 & 1954		GLOUCESTER RY. CARRIAGE & WAGON CO.	TORONTO TRANSIT COMMISSION	4
1953 & 1954		ST. LOUIS	CHICAGO TRANSIT COMMISSION	5
1954		ST. LOUIS	CLEVELAND TRANSIT SYSTEM	6
1954		ST. LOUIS	CLEVELAND TRANSIT SYSTEM	7
1955		GLOUCESTER RY. CARRIAGE & WAGON CO.	TORONTO TRANSIT COMMISSION	8
1955 & 1956		ST. LOUIS	CHICAGO TRANSIT AUTHORITY	9
1956 & 1957		ST. LOUIS	CHICAGO TRANSIT AUTHORITY	10
1956 & 1957		PULLMAN-STANDARD	METROPOLITAN TRANSIT AUTHORITY BOSTON	11
1957		ST. LOUIS	CLEVELAND TRANSIT SYSTEM	12
1957		ST. LOUIS	CLEVELAND TRANSIT SYSTEM	13

1957		ST. LOUIS	PORT AUTHORITY TRANS-HUDSON CORP.	14
1957		ST. LOUIS	PORT AUTHORITY TRANS-HUDSON CORP.	15
1958		ST. LOUIS	CHICAGO TRANSIT AUTHORITY	16
1958		ST. LOUIS	CHICAGO TRANSIT AUTHORITY	17
1959		BUDD	PHILADELPHIA TRANSPORTATION COMPANY	18
1959		BUDD	PHILADELPHIA TRANSPORTATION COMPANY	19
1962		MONTREAL LOCOMOTIVE	TORONTO TRANSIT COMMISSION	20
1962		PULLMAN-STANDARD	MASSACHUSETTS BAY TRANSIT AUTHORITY	21
1963		PULLMAN-STANDARD	CHICAGO TRANSIT AUTHORITY	22
1963		CANADIAN VICKERS	MONTREAL TRANSPORTATION COMMISSION	23
1963		CANADIAN VICKERS	MONTREAL TRANSPORTATION COMMISSION	24
1964		HAWKER-SIDDELEY	TORONTO TRANSIT COMMISSION	25
1964		ST. LOUIS	PORT AUTHORITY TRANS-HUDSON CORP.	26
1964		ST. LOUIS	PORT AUTHORITY TRANS-HUDSON CORP.	27
1966		PULLMAN-STANDARD	CLEVELAND TRANSIT SYSTEM	28
1966		ST. LOUIS	PORT AUTHORITY TRANS-HUDSON (A CARS)	29
1966		ST. LOUIS	PORT AUTHORITY TRANS-HUDSON (C CARS)	30
1966	IN OPERATION FEB. 1969	BUDD	PORT AUTHORITY TRANSIT CORP.	31
1966		HAWKER-SIDDELEY	MONTREAL	32

1967	JUNE 1969	BUDD	CHICAGO TRANSIT AUTHORITY	33
1968	IN OPERATION SEP. 1969	PULLMAN-STANDARD	MASSACHUSETTS BAY TRANSIT AUTHORITY	34
1969		ROHR	BAY AREA RAPID TRANSIT DISTRICT	35
1969	SUMMER 1971	ROHR	BAY AREA RAPID TRANSIT DISTRICT (B-CARS)	36
1970		PULLMAN-STANDARD	CLEVELAND TRANSIT SYSTEM	37
1970		HAWKER-SIDDELEY	TORONTO TRANSIT COMMISSION	38
1970		HAWKER-SIDDELEY	PORT-AUTHORITY TRANS-HUDSON (A CARS)	39
1972	SUMMER 1974	ROHR	WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY	40
1972		PULLMAN-STANDARD	NYC-MTA	41
1972	1973-1974	ROHR	BAY AREA RAPID TRANSIT DISTRICT	42

PART II. COST AND CHARACTERISTICS DATA

REFERENCE	CURRENT DOLLARS	1976 DOLLARS	TYPE OF CAR	SEATS PER CAR	DIMENSIONS	AVERAGE EMPTY WEIGHT (LB.)	MPH MAXIMUM SPEED
1	49,958	116,061	STEEL	48	L.49'9" H.11'9" W.8'7"	A CAR 47,700 B CAR 53,652	
2	37,736 38,983	84,164 89,011	ALUMINUM	50	L.48'3" H.11'10" W.9'4"	40,500	
3	76,950	121,273	STEEL	62	L.57' H.11'11' W.10'4"	84,370	
4	96,000	204,796	ALUMINUM	62	L.57' H.11'11" W.10'4"	73,440	
5	60,907 61,444 61,761	130,182 131,262 132,007	ALUMINUM	50	L.48'3" H.11'10" W.9'4"	42,000	
6	61,433	95,651	STEEL	54	L.48'9" H.11'9" W.10'4"	A CAR 54,658 B CAR 53,652	
7	70,676	150,097	STEEL	52	L.48'9" H.11'9" W.10'4"	56,620	
8	88,920	189,450	STEEL	62	L.57' H.11'11" W.10'4"	82,750 76,700	
9	68,648	145,135	ALUMINUM	A-47 B-51	L.48'3" H.11'10" W.9'4"	A CAR 40,800 B CAR 40,300	
10	68,648 61,882 62,653	141,578 127,211 129,213	ALUMINUM	A-47 B-51	L.48'3" H.11'10" W.9'4"	A CAR 42,600 A CAR 44,400 B CAR 42,250 B CAR 43,900	
11	74,987 80,000	154,650 164,989	STEEL	48	L.55'4" H.11'11" W.9'4"	A CAR 57,540 B CAR 58,620	
12	76,409	154,874	STEEL	54	L.48'9" H.11'9" W.10'4"	A CAR 53,245 B CAR 53,990	

13	83,117	168,470	STEEL	52	L.48'9" H.11'9" W.10'4"	57,050	
14	86,000	174,314	STEEL	44	L.51'3" H.11'8" W.8'10"	66,000	
15	96,000	194,583	STEEL	44	L.51'3" H.11'8" W.8'10"	68,000	
16	77,564	153,089	ALUMINUM	A-47 B-51	L.48'3" H.11'10" W.9'4"	A CAR 44,400 B CAR 43,900	
17	72,654 72,862 73,254	143,397 143,808 144,583	ALUMINUM	46	L.48'3" H.11'10" W.9'4"	44,900 44,600 45,700	50
18	97,616	191,068	STAIN- LESS STEEL	54	L.55'4" H.12'9" W.9'1"	51,300	55 (1)
19	88,756 89,013	173,726 174,229	STAIN- LESS STEEL	56	L.55'4" H.12'9" W,9'1"	48,730	55 (1)
20	107,097	202,029	ALUMINUM	84	L.74'9" H.11'11" W.10'4"	59,700	50 (1)
21	109,626	206,800	STEEL	54	L.69'10" H.12'6" W.10'4"	71,650 69,500	55
22	105,500	196,570	ALUMINUM	A-47 B-51	L.48'3" H.12'0" W.9'4"	46,890	65 (1)
23	133,868	249,426	STEEL	40	L.56'5" H.12' W.8'3"	60,000	50
24	76,973	143,418	STEEL	40	L.53'10" H.12' W.8'3"	44,000	50 (1)
25	98,920	181,881	ALUMINUM ALLOY	83	L.74'9" H.11'11" W.10'4"	55,340	50 (1)
26	111,485	204,985	ALUMINUM	43	L.51'3" H.11'8" W.9'3"	58,400	70

27	98,729	181,531	ALUMINUM	46	L.51'3" H.11'8" W.9'3"	55,800	70
28	171,208	301,017	STAIN- LESS STEEL & FIBER- GLASS	80	L.70'3" H.12' W.10'5"	64,775	55
29	128,925	226,675	ALUMINUM & FIBER- GLASS	41	L.51'3" H.11'8" W.9'3"	58,000	70
30	116,890	205,515	ALUMINUM & FIBER- GLASS	42	L.51'3" H.11'8" W.9'3"	55,300	70
31	191,000 (SNGLE) 178,000 (PAIR)	335,815 312,959	STAIN- LESS STEEL	72 80	L.67'10" H.12'4" W.10'2"	79,500 74,800	75
32	120,000	210,984	ALUMINUM	A-76 B-80	L.76'9" END 47'9" INTER H.6'9" W.10'4"	62,300 (END) 61,500	55
33	125,000	213,636	STAIN- LESS STEEL	A-47 B-51	L.48'3" H.12' W.9'4"	44,500	70
34	171,292 (SNGLE) 161,105 (PAIR)	280,837 264,136	ALUMINUM	60 64	L.69'10" H.12'4" W.10'	64,300 (SINGLE) 60,800 (PAIR)	70
35	233,100	362,779	ALUMINUM	72	L.75' H.10'6" W.10'6"	56,500	80
36	229,900	356,398	ALUMINUM ALLOY	72	L.70' H.10'6" W.10'6"	55,000	80
37	251,950	370,121	STAIN- LESS STEEL	80	L.70'3" H.12'0" W.10'5"	64,000	55
38	151,210	222,131	ALUMINUM	83	L.74'9" H.11'11" W.10'4"	55,500	55

39	184,000	270,301	ALUMINUM STAIN-LESS STEEL TRIM	33	L.51'3" H.11' W.9'3"	59,000	70
40	306,000	417,384		81	L.75' H.10' W.10'		75
41	298,000	406,472			L.75'		
42	370,000	504,680	ALUMINUM ALLOY	72	L.75' H.10'6" W.10'6"	56,500	80

(1) THESE CARS ARE CAPABLE OF HIGHER SPEEDS, BUT CONTROLS ARE SET TO CUT OFF AT APPROXIMATELY THE SPEED INDICATED.

SOURCES: INSTITUTE FOR RAPID TRANSIT (NOW APTA), "POST-WAR RAPID TRANSIT CARS," DATA BOOK ONE, APRIL, 1962, AND DATA BOOK TWO, SECOND EDITION, APRIL, 1965

IRT, RAPID TRANSIT CAR DATA BOOK THREE, 1971. IRT DIGESTS AND IRT NEWSLETTERS, 1971-1972

WALL STREET JOURNAL, OCTOBER 2, 1972, P. 8

TABLE B-12

COST OF COMMUTER RAIL ROLLING STOCK
(1965-1971)

CITY AND OPERATOR	LENGTH (FEET)	WIDTH (FEET)	HEIGHT (FEET)	WEIGHT (LBS.)	NO. SEATS	COST/CAR
CHICAGO	85	10.00	15.83	127,625 (3)	155	$200,000
C & NW				122,020 (4)	161	$180,487
				122,020 (4)	161	$169,770
CHICAGO	85	10.00	15.83	127,625 (3)	155	$212,236
ROCK ISLAND				122,020 (4)	161	$190,264
CHICAGO ILLINOIS CENTRAL	85	10.50	15.83	130,000 (EST.)	152	$307,564
CHICAGO	85	10.00	15.19	115,000 (3)	156	$245,307
BURLINGTON NORTHERN				110,000 (4)	168	$225,857
MONTREAL	85	10.00	15.19	115,000 (3)	156	$294,800
CANADIAN PACIFIC RAIL				110,000 (4)	168	$227,200
NEW YORK	85	10.50	13.00	91,600	118	$220,000
LONG ISLAND RAILROAD (MTA)						$225,000
NEW YORK-NORTH JERSEY N.J.DOT-PENN CENTRAL-JERSEY ARROW	85	10.50	12.67	114,883	118	$276,265
PHILADELPHIA SEPTA	85	10.13	12.7	104,000	122	$251,250
TORONTO	85	10.00	12.19	68,000 (1)	94	$210,000
GO TRANSIT CANADIAN NATIONAL				88,000 (2) (SELF-POWERED)	94	$220,000

(1) MOTOR CAR
(2) TRAILER
(3) CAB
(4) NONCAB

NOTE: COST DATA WERE COLLECTED BETWEEN 1965-1971.

SOURCE: OFFICE OF SYSTEMS ANALYSIS AND INFORMATION, <u>1972 NATIONAL TRANSPORTATION NEEDS STUDY: COST ESTIMATES FOR URBAN PUBLIC TRANSPORTATION</u>, U.S. DEPARTMENT OF TRANSPORTATION, WASHINGTON, D.C., JULY, 1971

APPENDIX C

LOCAL BUS AND BUS RAPID TRANSIT

TABLE C-1

CENTRAL BUSINESS DISTRICT BUS LANES

LOCATION AND STEEET	LENGTH OF BUS LANES (MILES)	APPROXIMATE AVERAGE SPEED (MPH)	DATE OF SURVEY
ATLANTA, GEORGIA			
PEACHTREE STREET	0.30	5.7	1958
BALTIMORE, MARYLAND			
PACA STREET	0.36	5.0	1958
CHICAGO, ILLINOIS			
WASHINGTON STREET	0.60	6.3	1971
NEWARK, NEW JERSEY			
MARKET STREET	0.34	6.0	1969
NEW YORK, NEW YORK			
5TH AVENUE	2.50	11.6	1969
MADISON AVENUE	1.12	1.9	1969
SAN FRANCISCO, CALIFORNIA			
O'FARREL STREET	0.65	7.3	1971
GEARY STREET	1.20	7.3	1971
VANCOUVER, B.C.			
GEORGIA STREET	0.80	10.7	1967
WEIGHTED AVERAGE	0.87	9.4	--

SOURCE: WILBUR SMITH AND ASSOCIATES, "DESIGN AND ANALYSIS OF BUS AND TRUCK ROADWAY SYSTEMS IN URBAN AREAS, PHASE I," NEW HAVEN, CONNECTICUT, NOVEMBER, 1973

TABLE C-2

ARTERIAL BUS LANES

LOCATION AND STREET	LENGTH OF BUS LANE (MILES)	APPROXIMATE AVERAGE SPEED (MPH)	DATE OF SURVEY
NEW YORK, NEW YORK			
2ND AVENUE	1.90	13.9	1969
1ST AVENUE	1.90	17.5	
TORONTO, ONTARIO			
EGLINTON AVENUE	1.40	14.3	1972
EGLINTON AVENUE	2.00	18.2	1972
DUBLIN, IRELAND			
FAIRVIEW DISTRICT	1.20	11.1	1971
WEIGHTED AVERAGE	1.68	15.4	--

SOURCES: WILBUR SMITH AND ASSOCIATES, "DESIGN AND ANALYSIS OF BUS AND TRUCK ROADWAY SYSTEMS IN URBAN AREAS, PHASE I," NEW HAVEN, CONNECTICUT, NOVEMBER, 1973

AMERICAN PUBLIC TRANSIT ASSOCIATION, <u>TRANSIT OPERATING REPORTS</u>, WASHINGTON, D.C., 1971-72

TABLE C-3

BUS ECONOMIC AND PERFORMANCE CHARACTERISTICS

VEHICLE TYPE	ENGINE	ACCELERATION IN MILES PER HOUR PER SECOND 0-10MPH	10-30MPH	30-50MPH	NORMAL DECELERATION IN MPHPS (1)
DIESEL BUS	GM V6-71	2.50	1.43	0.51	2-3
	GM V8-71	3.33	2.22	0.95	2-3
GASOLINE BUS	GASOLINE	2.50	1.50	0.60	2-3
GAS TURBINE BUS	TURBINE	2.00(2)	2.00(2)	1.00(2)	2-3
TROLLEY BUS	ELECTRIC	3.00(2)	2.00(2)	1.00(2)	2-3
TRANSBUS (SPECIFICATION)	ANY TYPE	2.22	2.30	0.92	2-3

CONTINUED BELOW

VEHICLE TYPE	ENGINE	TOP SPEED (MPH)	TYPICAL FUEL CONSUMPTION URBAN	RURAL	EMISSIONS AT VEHICLE(3) PRESENT	POTENTIAL
DIESEL BUS	GM V6-71	52	3.5MPG	---	HIGH	MEDIUM
	GM V8-71	65	3.6MPG	---	HIGH	MEDIUM
GASOLINE BUS	GASOLINE	55	3.3MPG	---	HIGH	MEDIUM
GAS TURBINE BUS	TURBINE	70(2)	3.0MPH	---	MEDIUM	LOW
TROLLEY BUS	ELECTRIC	60(2)	2-3 KWHR/MI		NONE	NONE
TRANSBUS (SPECIFICATION)	ANY TYPE	70	NOT SPECIFIED		MEDIUM	LOW

CONTINUED BELOW

VEHICLE TYPE	ENGINE	CAPITAL COSTS VEHICLE	POWER DISTRIBUTION (5)	VENTILATION (PER FOOT) (6)	
DIESEL BUS	GM V6-71	$40,000	NOT REQUIRED	$1,565	CONTINUED BELOW
	GM V8-71	42,000	NOT REQUIRED	1,565	
GASOLINE BUS	GASOLINE	38,500	NOT REQUIRED	1,175	
GAS TURBINE BUS	TURBINE	50,000	NOT REQUIRED	270	
TROLLEY BUS	ELECTRIC	50,000 (4)	$50,000/MILE	270	
TRANSBUS (SPECIFICATION)	ANY TYPE	N. A.	NOT REQUIRED	N. A.	

VEHICLE TYPE	ENGINE	OPERATING COSTS PER VEHICLE-MILE (7) FUEL	MAINTENANCE	POWER (10)
DIESEL BUS	GM V6-71	$0.10	$0.10	N.A. (11)
	GM V8-71	0.10	0.10	N.A. (11)
GASOLINE BUS	GASOLINE	0.17	0.20	N.A. (11)
GAS TURBINE BUS	TURBINE	0.12	0.20 (8)	N.A. (11)
TROLLEY BUS	ELECTRIC	NONE	0.10(9)	$0.03 (12)
TRANSBUS (SPECIFICATION)	ANY TYPE	N.A.	N.A.	N.A.

(1) LIMITED BY COMFORT AND SAFETY OF STANDING PASSENGERS.
(2) ESTIMATED BY EXTRAPOLATING AVAILABLE DATA.
(3) EXHAUST EMISSIONS: HIGH - FAILS FEDERAL 1974 REQUIREMENTS.
MEDIUM - MEETS FEDERAL 1974 REQUIREMENTS.
LOW - MEETS CALIFORNIA 1975 REQUIREMENTS.
(4) NOT MANUFACTURED IN U.S.A. HISTORICALLY COST OF TROLLEY BUSES HAS BEEN COMPETITIVE WITH DIESEL BUSES.
(5) PER FOOT OF TWO-LANE TUNNEL, 28-FOOT WALL-TO-WALL SECTION.
(6) INCLUDES DUCTWORK AND BUILDING.
(7) EXCLUDES DRIVERS' WAGES, OVERHEAD AND DEPRECIATION, WHICH WILL DEPEND ON OPERATING POLICY, MANAGEMENT, AND LOCATION RATHER THAN VEHICLE TECHNOLOGY.
(8) ESTIMATED TO BE TWICE DIESEL BUS MAINTENANCE.
(9) ASSUMES MAINTENANCE COMPARABLE TO DIESEL BUS.
(10) ASSUMING 300 VEHICLES PER HOUR IN BOTH DIRECTIONS PAST A POINT AND FOUR STATION STOPS PER MILE.
(11) VENTILATION FAN POWER REQUIREMENTS PER PEAK HOUR VEHICLE-MILE.
(12) APPROXIMATELY SAME AS DIESEL FUEL.

SOURCES: BOOZ-ALLEN APPLIED RESEARCH, "TRANSIT BUS PROPULSION SYSTEMS, STATE OF THE ART," TRANSBUS DOCUMENT TR72-002, AUGUST, 1972

HOFFMAN, G.A., "BUS DESIGN IMPROVEMENTS FOR THE BENEFIT OF NON-USERS," INSTITUTE OF TRAFFIC AND TRANSPORTATION ENGINEERING, UCLA, 1969

TABLE C-4

EXISTING OR PROPOSED BUSWAY CONSTRUCTION COSTS

	CONSTRUCTION COSTS			
	LENGTH (MILES)	COST ($1,000,000)	COST/ MILE	BASIC CONFIG-URATION
EAST-WEST TRANSITWAY (1) MILWAUKEE (PROPOSED)	8.0	$40.2	$5.0	AT GRADE
SAN BERNARDINO BUSWAY (2) LOS ANGELES (EXISTING)	11.0	54.0	4.9	AT GRADE
CROSSTOWN BUSWAY (3) CHICAGO (PROPOSED)	20.0	97.2	4.8	AT GRADE
SOUTH PATWAYS (4) PITTSBURGH (PROPOSED)	4.0	16.8	4.2	AT GRADE
NORTH CENTRAL BUSWAY (5) DALLAS (PROPOSED)	10.0	32.2	3.2	PARTIALLY ELEVATED
EAST PATWAYS (6) PITTSBURGH (PROPOSED)	8.0	21.4	2.7	AT GRADE
KCI TRANSITWAY (6) KANSAS CITY (PROPOSED)	19.0	29.5	1.6	AT GRADE
CANAL LINE BUSWAY (7) NEW HAVEN (PROPOSED)	13.3	15.0	1.1	AT GRADE
PENN CENTRAL BUSWAY (8) DAYTON (PROPOSED)	7.5	4.8	0.7	AT GRADE
SHIRLEY BUSWAY (9) WASHINGTON, D.C.(EXISTING)	5.0	2.8	0.7	AT GRADE

(1) 45 FOOT AVERAGE BUSWAY WIDTH
(2) PARTIAL USE OF SOUTHERN PACIFIC RAILROAD; 54 FOOT AVERAGE BUSWAY WIDTH
(3) SLIGHT CUT AND FILL; 44 FOOT AVERAGE BUSWAY WIDTH
(4) PARTIAL USE OF EXISTING TUNNEL; 36 FOOT AVERAGE BUSWAY WIDTH
(5) 33 FOOT AVERAGE BUSWAY WIDTH
(6) 36 FOOT AVERAGE BUSWAY WIDTH
(7) USE OF EXISTING ROW; 50 FOOT AVERAGE BUSWAY WIDTH
(8) USE OF EXISTING ROW; 32-42 FOOT AVERAGE BUSWAY WIDTH
(9) 12-28 FOOT AVERAGE BUSWAY WIDTH

NOTE: THE ABOVE CONSTRUCTION COSTS ASSUME A VARIETY OF CROSS SECTION DIMENSIONS.

SOURCES: WILBUR SMITH AND ASSOCIATES, "DESIGN AND ANALYSIS OF BUS AND TRUCK ROADWAY SYSTEMS IN URBAN AREAS," NEW HAVEN, CONNECTICUT, NOVEMBER, 1973

LEVINSON, H., HOEY, W., SANDERS, D., WYNN, H., BUS USE ON HIGHWAYS: STATE OF THE ART, NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM REPORT 143, WASHINGTON, D.C., 1973

TABLE C-5

BUS TRAFFIC ACCIDENTS
(PER MILLION BUS-MILES)

YEAR	VALUE	POPULATION RANGE (1000'S) 0-100	100-250	250-500	500-1000	OVER 1000
1971	DEFAULT	72.73	55.49	54.85	48.15	67.58
	RANGE	6.85-254.07	21.13-143.89	22.52-93.54	6.74-111.83	16.23-105.17
	NO. OF BUS COMPANIES SAMPLED	11	16	18	20	19
1972	DEFAULT	91.16	57.61	62.31	48.17	66.73
	RANGE	.03-123.21	19.21-154.42	18.99-93.18	3.91-93.44	17.64-108.14
	NO. OF BUS COMPANIES SAMPLED	11	17	18	20	19
WEIGHTED AVERAGE	DEFAULT	82.55	56.60	58.84	48.16	67.16
	RANGE	.03-254.07	19.21-154.42	18.99-93.54	3.91-111.83	16.23-108.14

NOTE: WEIGHTED AVERAGE (WEIGHTED BY THE NUMBER OF LINE-MILES OF EACH BUS COMPANY) CHOSEN AS THE DEFAULT VALUE, ASSUMING ACCIDENTS ARE A FUNCTION OF TIME OR DISTANCE SPENT ON THE ROAD.

BUS TRAFFIC ACCIDENTS INCLUDE COLLISIONS WITH PEDESTRIANS, OTHER BUSES, AND OTHER VEHICLES AND OBJECTS.

SOURCE: AMERICAN TRANSIT ASSOCIATION, <u>ACCIDENT OPERATING STATISTICS</u>, WASHINGTON, D.C., 1971-72

TABLE C-6

BUS PASSENGER ACCIDENTS
(PER MILLION BUS-MILES)

YEAR	VALUE	POPULATION RANGE (1000'S) 0-100	100-250	250-500	500-1000	OVER 1000
1971	DEFAULT	14.18	15.55	18.69	19.78	21.08
	RANGE	2.74-23.64	3.78-33.31	2.04-34.34	1.82-49.24	5.73-33.94
	NO. OF BUS COMPANIES SAMPLED	11	16	16	20	10
1972	DEFAULT	10.38	16.66	15.81	17.73	22.05
	RANGE	0.83-37.42	4.83-34.40	0.42-109.24	2.10-47.99	5.61-33.63
	NO. OF BUS COMPANIES SAMPLED	11	17	16	20	10
AVERAGE OF ABOVE	DEFAULT	12.20	16.13	17.15	18.76	21.50
	RANGE	0.83-37.42	3.78-34.40	0.42-109.24	1.82-49.24	5.61-33.94

NOTE: WEIGHTED AVERAGE (WEIGHTED BY THE NUMBER OF PASSENGERS CARRIED BY EACH BUS COMPANY) CHOSEN AS THE DEFAULT VALUE, ASSUMING PASSENGER ACCIDENTS ARE A FUNCTION OF DEMAND.

BUS PASSENGER ACCIDENTS INCLUDE BOARDING, ALIGHTING, DOOR RELATED, AND ALL RECORDED ON-BOARD ACCIDENTS.

FATALITIES ARE INCLUDED IN THE ABOVE DATA.

SOURCE: AMERICAN TRANSIT ASSOCIATION (NOW APTA), ACCIDENT OPERATING STATISTICS, WASHINGTON., D.C., 1971-72

APPENDIX D

AUTOMOBILE-HIGHWAY SYSTEM

TABLE D-1

DESIGN CAPACITY(VPH) (1) OF SIGNALIZED INTERSECTIONS
LEVEL OF SERVICE 'C' (2)
ONE-WAY STREET OPERATION IN CBD. (3)

INTERSECTION APPROACH WIDTH - NO PARKING

G/C	20'	22'	24'	26'	27'	30'	33'
0.20	325	355	375	415	445	500	540
0.25	400	440	470	520	545	620	670
0.30	475	530	570	625	650	740	810
0.33	530	575	630	680	715	815	890
0.35	560	630	670	740	760	865	945
0.40	640	700	760	840	865	980	1070
0.45	730	800	860	940	970	1120	1215
0.50	810	875	955	1045	1075	1240	1340
0.55	890	975	1060	1150	1200	1360	1480
0.60	960	1050	1150	1255	1300	1480	1600
0.66	1060	1160	1255	1375	1430	1625	1775
0.70	1130	1230	1330	1460	1515	1725	1875
0.75	1210	1320	1435	1565	1630	1860	2020
0.80	1300	1410	1530	1675	1730	1985	2150
0.90	1455	1590	1710	1880	1945	2220	2420
1.00	1615	1760	1905	2090	2165	2475	2690

CONTINUED BELOW

INTERSECTION APPROACH WIDTH - NO PARKING

G/C	36'	40'	44'	48'	50'	55'	60'
0.20	600	665	730	805	835	910	1000
0.25	750	835	915	1000	1050	1145	1250
0.30	900	1000	1100	1200	1255	1360	1500
0.33	990	1100	1215	1330	1375	1510	1650
0.35	1050	1160	1275	1400	1465	1600	1750
0.40	1190	1320	1455	1600	1660	1820	2000
0.45	1350	1500	1650	1805	1880	2055	2250
0.50	1490	1660	1830	2020	2090	2280	2500
0.55	1650	1830	2010	2205	2300	2510	2750
0.60	1800	2000	2200	2410	2510	2740	3000
0.66	1965	2180	2415	2650	2750	3000	3295
0.70	2085	2320	2560	2800	2930	3180	3480
0.75	2250	2490	2750	3010	3140	3430	3755
0.80	2400	2660	2925	3200	3350	3645	4000
0.90	2690	2980	3295	3600	3755	4100	4500
1.00	2990	3305	3655	4010	4185	4560	4900

(1) THE DESIGN CAPACITIES INDICATED FOR LEVEL OF SERVICE 'C' ARE BASED ON THE FOLLOWING 'AVERAGE CONDITIONS':
A. 5% TRUCKS AND THROUGH BUSES
B. 10% RIGHT TURNS
C. 10% LEFT TURNS
D. METRO POPULATION SIZE 250,000(4) WITH CORRESPONDING PEAK HOUR FACTOR OF 0.85(5)

(2) TO OBTAIN DESIGN CAPACITIES OTHER THAN LEVEL OF SERVICE 'C', MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

LEVEL OF	APPROACH WIDTH					
SERVICE	20'	25'	30'	35'	40'	50'	60'
D	1.12	1.09	1.07	1.07	1.08	1.11	1.13
E	1.15	1.13	1.12	1.12	1.13	1.15	1.17

(3) TO OBTAIN DESIGN CAPACITIES FOR AREAS OTHER THAN CBD, MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

AREA	FACTOR
CBD	1.00
FRINGE	1.10
OBD	1.10
RESIDENTIAL	1.20

(4) TO OBTAIN DESIGN CAPACITIES FOR METRO POPULATION SIZES OTHER THAN 250,000, MULTIPLY THE VOLUMES BY THE FOLLOWING FACTORS:

METRO POPULATION SIZE	FACTOR
OVER 1,000,000	1.20
1,000,000	1.15
750,000	1.10
500,000	1.05
250,000	1.00
175,000	0.95
100,000	0.90
50,000	0.85

(5) TO OBTAIN DESIGN CAPACITIES FOR PEAK HOUR FACTOR OTHER THAN 0.85, DIVIDE THE VOLUME SHOWN BY 0.85 AND MULTIPLY THE RESULT BY KNOWN OR MEASURED PHF.

NOTE: TO CORRECT FOR BUSES, SEE APPENDIX, FIGURE D-1, IN CUTS MANUAL.

SOURCE: TABLES PREPARED BY M. P. O'DWYER FROM J. E. LEISCH NOMOGRAPHS AND 1965 HIGHWAY CAPACITY MANUAL

TABLE D-2

DESIGN CAPACITY(VPH) (1) OF SIGNALIZED INTERSECTIONS
LEVEL OF SERVICE 'C' (2)
ONE-WAY STREET OPERATION IN CBD. (3)

	INTERSECTION APPROACH WIDTH - PARKING - ONE SIDE ONLY											
G/C	20'	22'	30'	32'	38'	41'	44'	48'	52'	56'	58'	60'
0.20	160	200	325	355	450	500	545	610	670	730	760	790
0.25	200	250	405	450	555	625	680	755	840	910	950	990
0.30	250	305	490	540	680	755	815	910	1005	1095	1145	1185
0.33	270	330	535	590	745	820	900	1000	1100	1200	1250	1300
0.35	290	355	565	625	780	870	950	1055	1165	1265	1320	1370
0.40	330	400	650	720	900	995	1080	1210	1335	1450	1510	1570
0.45	370	455	735	810	1000	1120	1225	1360	1500	1635	1700	1770
0.50	415	505	815	900	1125	1250	1355	1515	1670	1815	1900	1970
0.55	455	550	900	990	1230	1370	1490	1660	1830	2000	2080	2160
0.60	500	610	975	1080	1345	1500	1630	1810	2000	2180	2270	2360
0.66	550	660	1070	1180	1470	1640	1790	1985	2190	2380	2500	2600
0.70	580	710	1150	1255	1560	1745	1900	2115	2335	2540	2650	2745
0.75	625	765	1220	1350	1680	1865	2040	2260	2510	2730	2850	2955
0.80	665	805	1300	1440	1790	1995	2160	2415	2660	2900	3035	3140
0.90	755	920	1475	1620	2025	2250	2450	2725	3000	3280	3415	3550
1.00	830	1020	1630	1790	2235	2485	2720	3030	3335	3640	3800	3935

(1) THE DESIGN CAPACITIES INDICATED FOR LEVEL OF SERVICE 'C' ARE BASED ON THE FOLLOWING 'AVERAGE CONDITIONS':
- A. 5% TRUCKS AND THROUGH BUSES
- B. 10% RIGHT TURNS
- C. 10% LEFT TURNS
- D. METRO POPULATION SIZE 250,000 (4) WITH CORRESPONDING PEAK HOUR FACTOR OF 0.85 (5)

(2) TO OBTAIN DESIGN CAPACITIES OTHER THAN LEVEL OF SERVICE 'C', MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

LEVEL OF	APPROACH WIDTH						
SERVICE	20'	25'	30'	35'	40'	50'	60'
D	1.07	1.08	1.10	1.12	1.14	1.10	1.22
E	1.10	1.13	1.16	1.18	1.20	1.25	1.30

(3) TO OBTAIN DESIGN CAPACITIES FOR AREAS OTHER THAN CBD, MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

AREA	FACTOR
CBD	1.00
FRINGE	1.00
OBD	1.20
RESIDENTIAL	1.20

(4) TO OBTAIN DESIGN CAPACITIES FOR METRO POPULATION SIZES OTHER THAN 250,000, MULTIPLY THE VOLUMES BY THE FOLLOWING FACTORS:

METRO POPULATION SIZE	FACTOR
OVER 1,000,000	1.20
1,000,000	1.15
750,000	1.10
500,000	1.05
250,000	1.00
175,000	0.95
100,000	0.90
50,000	0.85

(5) TO OBTAIN DESIGN CAPACITIES FOR PEAK HOUR FACTOR OTHER THAN 0.85, DIVIDE THE VOLUME SHOWN BY 0.85 AND MULTIPLY THE RESULT BY KNOWN OR MEASURED PHF.

NOTE: TO CORRECT FOR BUSES, SEE APPENDIX, FIGURE D-1, IN CUTS MANUAL.

SOURCE: TABLES PREPARED BY M. P. O'DWYER FROM J. E. LEISCH NOMOGRAPHS AND 1965 HIGHWAY CAPACITY MANUAL

TABLE D-3

DESIGN CAPACITY (VPH) (1) OF SIGNALIZED INTERSECTIONS
LEVEL OF SERVICE 'C' (2)
ONE-WAY STREET OPERATION IN CBD. (3)

G/C	INTERSECTION APPROACH WIDTH - PARKING BOTH SIDES										
	26'	27'	28'	36'	38'	40'	46'	49'	52'	56'	60'
0.20	185	205	220	345	380	410	500	545	590	645	705
0.25	230	255	280	425	480	510	625	690	745	815	895
0.30	280	310	335	520	565	615	760	830	895	975	1065
0.33	315	345	370	580	630	680	845	920	990	1075	1185
0.35	330	370	395	610	660	725	895	975	1050	1150	1250
0.40	380	420	450	700	760	830	1020	1115	1195	1305	1480
0.45	435	470	505	800	860	940	1160	1250	1340	1460	1600
0.50	475	525	555	875	955	1030	1260	1400	1500	1630	1775
0.55	525	575	620	970	1050	1145	1400	1535	1645	1800	1960
0.60	580	635	675	1055	1155	1250	1530	1675	1800	1965	2145
0.66	635	695	745	1160	1265	1370	1680	1840	1975	2155	2350
0.70	670	735	795	1230	1340	1460	1775	1950	2095	2230	2500
0.75	725	800	850	1330	1445	1560	1910	2100	2250	2460	2680
0.80	760	845	905	1400	1530	1665	2040	2235	2400	2615	2850
0.90	870	955	1020	1580	1725	1870	2290	2505	2695	2935	3200
1.00	970	1055	1140	1765	1920	2080	2550	2795	2995	3270	3570

(1) THE DESIGN CAPACITIES INDICATED FOR LEVEL OF SERVICE 'C' ARE BASED ON THE FOLLOWING 'AVERAGE CONDITIONS':
- A. 5% TRUCKS AND THROUGH BUSES
- B. 10% RIGHT TURNS
- C. 10% LEFT TURNS
- D. METRO POPULATION SIZE 250,000(4) WITH CORRESPONDING PEAK HOUR FACTOR OF 0.85(5)

(2) TO OBTAIN DESIGN CAPACITIES OTHER THAN LEVEL OF SERVICE 'C', MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

LEVEL OF SERVICE	APPROACH WIDTH 25'	30'	35'	40'	50'	60'
D	1.17	1.17	1.17	1.18	1.22	1.25
E	1.25	1.25	1.25	1.27	1.32	1.37

(3) TO OBTAIN DESIGN CAPACITIES FOR AREAS OTHER THAN CBD, MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

AREA	FACTOR
CBD	1.00
FRINGE	1.00
OBD	1.15
RESIDENTIAL	1.25

(4) TO OBTAIN DESIGN CAPACITIES FOR METRO POPULATION SIZES OTHER THAN 250,000, MULTIPLY THE VOLUMES BY THE FOLLOWING FACTORS:

METRO POPULATION SIZE	FACTOR
OVER 1,000,000	1.20
1,000,000	1.15
750,000	1.10
500,000	1.05
250,000	1.00
175,000	0.95
100,000	0.90
50,000	0.85

(5) TO OBTAIN DESIGN CAPACITIES FOR PEAK HOUR FACTOR OTHER THAN 0.85, DIVIDE THE VOLUME SHOWN BY 0.85 AND MULTIPLY THE RESULT BY KNOWN OR MEASURED PHF.

NOTE: TO CORRECT FOR BUSES, SEE APPENDIX, FIGURE D-1, IN CUTS MANUAL.

SOURCE: TABLES PREPARED BY M. P. O'DWYER FROM J. E. LEISCH NOMOGRAPHS AND 1965 HIGHWAY CAPACITY MANUAL

TABLE D-4

DESIGN CAPACITY(VPH) (1) OF SIGNALIZED INTERSECTIONS
LEVEL OF SERVICE 'C' (2)
TWO-WAY STREET OPERATION IN CBD. (3)

INTERSECTION APPROACH WIDTH - NO PARKING

G/C	10'	11'	12'	13'	18'	20'	22'	24'
0.20	130	145	155	175	245	265	300	330
0.25	155	175	200	210	300	335	375	410
0.30	190	220	240	260	370	405	460	500
0.33	210	235	255	275	400	435	500	550
0.35	215	255	280	300	435	470	535	575
0.40	255	280	310	345	500	540	610	660
0.45	290	325	355	400	555	615	680	750
0.50	325	360	400	435	620	675	765	835
0.55	355	400	430	460	680	740	840	915
0.60	390	430	470	520	740	810	915	1000
0.66	440	500	545	600	830	900	1020	1100
0.70	450	500	550	600	860	945	1060	1155
0.75	480	545	600	650	920	1015	1140	1240
0.80	515	570	625	695	1000	1090	1215	1330
0.90	585	645	715	775	1110	1215	1380	1490
1.00	645	715	790	855	1230	1355	1530	1655

CONTINUED BELOW

INTERSECTION APPROACH WIDTH - NO PARKING

G/C	26'	27'	30'	33'	36'	40'	44'	48'
0.20	360	375	415	455	495	550	600	650
0.25	455	465	520	570	620	685	750	815
0.30	550	570	630	690	750	830	905	980
0.33	600	620	680	750	815	905	980	1075
0.35	635	660	730	800	860	960	1055	1150
0.40	725	750	835	910	1000	1100	1200	1310
0.45	820	850	940	1030	1120	1240	1355	1470
0.50	910	950	1040	1140	1240	1380	1510	1650
0.55	1005	1040	1150	1260	1360	1515	1660	1805
0.60	1100	1135	1255	1370	1490	1650	1805	1960
0.66	1210	1255	1390	1505	1640	1815	1990	2160
0.70	1270	1320	1460	1600	1730	1925	2105	2295
0.75	1370	1415	1565	1710	1850	2060	2260	2455
0.80	1460	1510	1675	1825	1980	2200	2400	2620
0.90	1640	1700	1880	2055	2220	2470	2700	2940
1.00	1825	1885	2080	2280	2480	2740	3000	3265

(1) THE DESIGN CAPACITIES INDICATED FOR LEVEL OF SERVICE 'C' ARE BASED ON THE FOLLOWING 'AVERAGE CONDITIONS':

A. 5% TRUCKS AND THROUGH BUSES
B. 10% RIGHT TURNS
C. 10% LEFT TURNS
D. METRO POPULATION SIZE 250,000(4) WITH CORRESPONDING PEAK HOUR FACTOR OF 0.85(5)

(2) TO OBTAIN DESIGN CAPACITIES OTHER THAN LEVEL OF SERVICE 'C', MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

LEVEL OF SERVICE	APPROACH WIDTH 10'	15'	20'	25'	30'	35'	40'	50'	60'
D	1.14	1.14	1.14	1.14	1.15	1.16	1.17	1.18	1.20
E	1.20	1.20	1.20	1.20	1.21	1.23	1.25	1.27	1.30

(3) TO OBTAIN DESIGN CAPACITIES FOR AREAS OTHER THAN CBD, MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

AREA	FACTOR
CBD	1.00
FRINGE	1.25
OBD	1.25
RESIDENTIAL	1.25

(4) TO OBTAIN DESIGN CAPACITIES FOR METRO POPULATION SIZES OTHER THAN 250,000, MULTIPLY THE VOLUMES BY THE FOLLOWING FACTORS:

METRO POPULATION SIZE	FACTOR
OVER 1,000,000	1.20
1,000,000	1.15
750,000	1.10
500,000	1.05
250,000	1.00
175,000	0.95
100,000	0.90
50,000	0.85

(5) TO OBTAIN DESIGN CAPACITIES FOR PEAK HOUR FACTOR OTHER THAN 0.85, DIVIDE THE VOLUME SHOWN BY 0.85 AND MULTIPLY THE RESULT BY KNOWN OR MEASURED PHF.

NOTE: TO CORRECT FOR BUSES, SEE APPENDIX, FIGURE D-1, IN CUTS MANUAL.

SOURCE: TABLES PREPARED BY M. P. O'DWYER FROM J. E. LEISCH NOMOGRAPHS AND 1965 HIGHWAY CAPACITY MANUAL

TABLE D-5

DESIGN CAPACITY(VPH) (1) OF SIGNALIZED INTERSECTIONS
LEVEL OF SERVICE 'C' (2)
TWO-WAY STREET OPERATION IN CBD. (3)

G/C	20'	22'	24'	26'	27'	30'	33'	36'	40'	44'	48'
	INTERSECTION APPROACH WIDTH - WITH PARKING										
0.20	200	225	240	265	270	305	335	360	400	440	480
0.25	245	275	295	330	340	380	415	455	500	550	600
0.30	300	340	365	400	405	455	500	550	605	660	725
0.33	330	370	400	435	445	500	550	600	665	720	795
0.35	345	385	420	460	470	535	580	630	700	770	845
0.40	400	450	490	530	545	610	665	730	805	875	965
0.45	445	500	550	595	610	680	750	815	900	980	1095
0.50	500	560	605	670	685	765	840	910	1015	1100	1210
0.55	550	610	670	720	750	840	910	1000	1100	1200	1330
0.60	600	675	730	800	815	920	1000	1100	1210	1320	1455
0.66	655	730	800	865	885	1000	1100	1195	1325	1450	1585
0.70	700	780	850	915	955	1065	1170	1270	1400	1530	1680
0.75	750	835	910	990	1010	1140	1250	1380	1505	1645	1815
0.80	800	900	970	1060	1090	1215	1330	1455	1615	1755	1935
0.90	900	1005	1095	1190	1225	1370	1500	1645	1800	1970	2170
1.00	1000	1115	1200	1330	1355	1530	1670	1820	2000	2195	2415

(1) THE DESIGN CAPACITIES INDICATED FOR LEVEL OF SERVICE 'C' ARE BASED ON THE FOLLOWING 'AVERAGE CONDITIONS':

A. 5% TRUCKS AND THROUGH BUSES
B. 10% RIGHT TURNS
C. 10% LEFT TURNS
D. METRO POPULATION SIZE 250,000(4) WITH CORRESPONDING PEAK HOUR FACTOR OF 0.85(5)

(2) TO OBTAIN DESIGN CAPACITIES OTHER THAN LEVEL OF SERVICE 'C', MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

LEVEL OF SERVICE	APPROACH WIDTH 20'	25'	30'	35'	40'	50'	60'
D	1.06	1.09	1.11	1.14	1.17	1.22	1.24
E	1.10	1.14	1.18	1.21	1.25	1.31	1.34

(3) TO OBTAIN DESIGN CAPACITIES FOR AREAS OTHER THAN C.B.D., MULTIPLY VOLUMES SHOWN BY THE FOLLOWING FACTORS:

AREA	FACTOR
CBD	1.00
FRINGE	1.25
OBD	1.25
RESIDENTIAL	1.25

(4) TO OBTAIN DESIGN CAPACITIES FOR METRO POPULATION SIZES OTHER THAN 250,000, MULTIPLY THE VOLUMES BY THE FOLLOWING FACTORS:

METRO POPULATION SIZE	FACTOR
OVER 1,000,000	1.20
1,000,000	1.15
750,000	1.10
500,000	1.05
250,000	1.00
175,000	0.95
100,000	0.90
50,000	0.85

(5) TO OBTAIN DESIGN CAPACITIES FOR PEAK HOUR FACTOR OTHER THAN 0.85, DIVIDE THE VOLUME SHOWN BY 0.85 AND MULTIPLY THE RESULT BY KNOWN OR MEASURED PHF.

NOTE: TO CORRECT FOR BUSES, SEE APPENDIX, FIGURE D-1, IN CUTS MANUAL.

SOURCE: TABLES PREPARED BY M. P. O'DWYER FROM J. E. LEISCH NOMOGRAPHS AND 1965 HIGHWAY CAPACITY MANUAL

TABLE D-6

HOURLY DISTRIBUTION OF ACCIDENTS - 1972

HOURS	FATAL ACCIDENTS (PERCENT)	ALL ACCIDENTS (PERCENT)
MIDNIGHT TO 3 A.M.	14.6	7.0
3 A.M. TO 6 A.M.	5.9	2.7
6 A.M. TO 9 A.M.	7.2	6.2
9 A.M. TO NOON	8.8	12.4
NOON TO 3 P.M.	11.9	17.2
3 P.M. TO 6 P.M.	18.2	24.8
6 P.M. TO 9 P.M.	17.8	15.1
9 P.M. TO MIDNIGHT	15.6	10.6

TABLE D-7

TYPES OF URBAN ACCIDENTS - 1972

	FATAL ACCIDENTS (PERCENT)	ALL ACCIDENTS (PERCENT)
PEDESTRIAN	39.9	3.0
INTERSECTION	15.1	1.1
NON INTERSECTION	24.8	1.9
TWO MOTOR VEHICLE	32.2	85.2
INTERSECTION	18.1	36.5
NON INTERSECTION	14.1	48.7
OTHER COLLISIONS	13.8	5.7
INTERSECTION	3.6	1.7
NON INTERSECTION	10.2	4.0
NON COLLISION	14.1	6.1
RAN OFF ROAD	12.1	4.9
OTHER	2.0	1.2

SOURCE: NATIONAL SAFETY COUNCIL, "ACCIDENT FACTS," 1973 EDITION.

APPENDIX E

ACTIVITY CENTER SYSTEMS

TABLE E-1

SYSTEM DESCRIPTIONS

SYSTEM NAME AND LOCATION	COMPANY (DATE OPENED)	DESCRIPTION	COST
AIRTRANS DALLAS-FT. WORTH AIRPORT	LTV AERO-AEROSPACE (JAN.1974)	13 MILE OF ONE-WAY GUIDE GUIDEWAY,51 PASSENGER VEHICLES, 17 UTILITY VEHICLES, 14 PASSENGER STATIONS, 5 BAGGAGE/MAIL STOPS, 9 SUPPLY STOPS, 9 TRASH STOPS, A CENTRAL CONTROL FACILITY. GUIDE-WAY IS 20% AT GRADE, 80% ELEVATED.	$31 MILL + $4.5 MILL FOR MAIN-TENANCE FACILITY
ACT FAIRLANE SHOPPING CENTER, DEARBORN MICHIGAN	FORD (UNDER CON-STRUCTION, TO BE COM-PLETED 1975)	TWO VEHICLES TO SHUTTLE 3200 FT. PEAK CAPACITY 500 PASS/HR. TRAVEL TIME 71 SEC, DWELL 25 SEC, AVERAGE SPEED 19 MPH	$4 MILL
ACT BRADLEY INTER-NATIONAL AIRPORT, HARTFORD, CONN.	FORD (UNDER CON-STRUCTION, TO BE COM-PLETED 1975)	TWO 24 PASSENGER VEHICLES TO SHUTTLE 3/4 MILE. CAPACITY 800 PER HOUR. 50% ELEVATED GUIDEWAY	$4.4 MILL
ACT EL PASO, TEXAS; JUAREZ, MEXICO	FORD (UNDER CON-STRUCTION)	SYSTEM TO SPAN RIO GRANDE. FOUR VEHICLES AND 1.5 MILE OF ELEVATED GUIDEWAY.	$14-15 MILL
DASHAVEYOR TORONTO ZOO	BENDIX CORP. (UNDER CON-STRUCTION, OPERATIONAL LATE 1975)	THREE MILES OF SINGLE GUIDEWAY. FOUR STATIONS 24 FORTY-PASSENGER VEHICLES FOR TWO AND FOUR VEHICLE TRAINS	$12 MILL
SKYBUS TAMPA AIRPORT, FLORIDA	WESTING-HOUSE (BEGAN SERVICE 1971	7132 FT OF SINGLE LAND GUIDEWAY, 8 VEHICLES AND CONTROL SYSTEMS, 64 PLATFORM DOORS, 5 MAIN-TENANCE FACILITIES	$5.5 MILL

SKYBUS SEA-TAC SEATTLE AIRPORT, WASHINGTON	WESTING-HOUSE (BEGAN SERVICE 1972)	9050 FT OF SINGLE LANE GUIDEWAY, 10 VEHICLES, 9 SOUTH LOOP CONTROL BLOCKS, 11 NORTH LOOP CONTROL BLOCKS, 8 STA-TIONS, 2 MAINTENANCE FACILITIES	$5.3 MILL
ROHR P HOUSTON AIRPORT	ROHR (BEGAN SERVICE 1972)	1 MILE OF SINGLE GUIDE-WAY, 6 TRAINS OF 3 CARS, AND 8 STATIONS	$.8 MILL (BASED ON UNIT PRICES)
ROHR N SAN DIEGO WILD ANIMAL PARK	ROHR (OPERATION-AL 1973)	5 MILES OF SINGLE GUIDE-WAY, 13 TRAINS OF 2 VEHICLES, AND 2 STATIONS	$5 MILL (BASED ON UNIT PRICES
CARVEYOR FIRM QUOTATIONS FOR TAMPA AIRPORT	GOODYEAR	7280 FT AND 7 LOOPS	$9.3 MILL
FIRM QUOTATIONS FOR A SEATTLE INSTALLATION	GOODYEAR	1 MILE OF GUIDEWAY	$5.6 MILL
JETRAIL LOVE FIELD DALLAS, TEXAS	MOBILITY SYSTEMS AND EQUIPT. CO. (OPERATION- AL 1973	8460 FT OF GUIDEBEAM, 10 VEHICLES, 2 STATIONS	$1.4 MILL
MORGANTOWN MORGANTOWN, WEST VIRGINIA	PRIME CONTRACTOR BOEING (PARTLY OPERATION-AL 1973)	2.2 MILES OF GUIDEWAY, 3 STATIONS, 5 VEHICLES, 80% OF GUIDEWAY ABOVE GRADE, MAINTENANCE AND CONTROL FACILITY	$40 MILL

TABLE E-2

ACTIVITY CENTER SYSTEMS
IN USE, FOR DEMONSTRATION, OR UNDER CONSTRUCTION

<u>ZOO/PARK/AMUSEMENT PARK</u>	
TORONTO ZOO	DASHAVEYOR
ATLANTIC CITY, N. J.	ROHR J
SAN ANTONIO, TEXAS, HEMISFAIR	ROHR J
PALISADES PARK, N. J.	ROHR J
LAKE GEAUGA, OHIO	ROHR J
BRONX ZOO, N. Y. CITY	ROHR J
OKLAHOMA STATE FAIR GROUNDS	ROHR K
OCEAN CITY, MD.	ROHR K
WILDWOOD, N. J.	ROHR K
DUTCH WONDERLAND, LANCASTER, PA.	ROHR K
SAN DIEGO WILD ANIMAL PARK	ROHR N
MONTREAL EXPO	UNIMOBIL
HERSHEY PARK, PA.	UNIMOBIL
CHARLOTTE, N. C.	UNIMOBIL
YATSU PARK IN CHIHA PIE	VONA
BUSCH GARDENS, WILLIAMSBURG, VA.	SKYBUS
L. A. COUNTRY FAIRGROUND	DASHAVEYOR
DISNEYLAND, CALIFORNIA	WEDWAY/CARVEYOR
DISNEYWORLD, FLORIDA	ALWEG/MONORAIL
<u>DEMONSTRATION TRACKS</u>	
CHERRY HILL TEST FACILITY, DEARBORN, MICHIGAN	ACT
ANN ARBOR, MICHIGAN	DASHAVEYOR
PONTIAC, MICHIGAN	INSTA GLIDE
KOWASAKI	KCV
MITSUBISHI	MAT
TOSHIBA	MINI MONORAIL
JAPAN/TOHU CAR MFG.	PARATRAN
FRANCE/GRENOBLE	POMA 2000
CAPE MAY COUNTY AIRPORT, N.Y.	ROHR J
CAPE MAY COUNTY AIRPORT, N.Y.	ROHR K
CAPE MAY COUNTY AIRPORT, N.Y.	ROHR M
BEDFORD, MASSACHUSETTS	STARRCAR
GRENOBLE	TELERAIL
MUNICH	TRANSURBAN
MINNEAPOLIS	UNIFLOW
FRANCE	URBA 30
FRANCE	VAL
JAPAN/TOYOKAWA	VONA
SOUTH PARK, PA.	SKYBUS
HAMMOND, INDIANA	AERIAL TRANSIT SYSTEM--PULLMAN
EL SEGUNDO	AEROSPACE--SCALED
ORLY AIRPORT	ARAMIS
HAGEN	CABINENTAXI
TOKYO	CVS
GARLAND, TEXAS	MONOCAB
CHULA VISTA, CALIF.	MONOCAB
GOMETZ, FRANCE	AEROTRAIN
<u>AIRPORTS</u>	
DALLAS-FORT WORTH	AIRTRANS

BRADLEY, HARTFORD, CONN.	ACT
HOUSTON	ROHR P
TAMPA, FLORIDA	SKYBUS
SEA-TAC/SEATTLE, WASH.	SKYBUS
MIAMI	SKYBUS
LOVE FIELD, DALLAS	JETRAIL
HANEDA LINE, TOKYO	ALWEG
<u>SHOPPING CENTERS</u>	
FAIRLANE, DEARBORN, MICHIGAN	ACT
HONOLULU, HAWAII	ROHR
<u>COMMUNITIES</u>	
EL PASO/JUAREZ	ACT
LILLE/VILLENEUVE-D'ASCG	VAL
NANCY, FRANCE	TTI/OTIS
ORLEANS, FRANCE	AEROTRAIN

APPENDIX F

PEDESTRIAN ASSISTANCE SYSTEMS

TABLE F-1

SELECTED MOVING WALKWAYS (LOCATIONS AND PARAMETERS)

	TYPE OF APPLICATION				
CITIES: DOMESTIC	CBD	COMMUTER STATION	AIRPORT	CAMPUS	PUBLIC PARKS/ZOOS
AKRON	X	X	X		
ATLANTA					
AKRON	X	X		X	
ATLANTA	X		X		
BOSTON	X	X	X	X	
CHIAAGO			X		
CLEVELAND	X				
COLUMBUS	X				
HARTFORD	X				
HOUSTON	X		X		
INGLEWOOD	X				
LAS VEGAS	X		X		
LOS ANGELES	X		X		
MIAMI	X		X		
MINNEAPOLIS					X
NEW YORK	X	X	X		X
PHILADELPHIA	X				
PITTSBURGH	X				
PORTLAND	X				
RESTON		X			
SAN DIEGO	X				
SAN FRANCISCO	X		X		
SAN JOSE	X			X	
SEATTLE			X		
ST. LOUIS			X		
WASHINGTON		X			
CITIES: FOREIGN					
MANCHESTER, ENG.					
MONTREAL, CAN.					
MUNICH, GERMANY			X		
PARIS, FRANCE	X		X		
OTTAWA, CAN.	X				
TORONTO, CAN.	X				

CONTINUED BELOW

TYPICAL PARAMETERS

	SYSTEM LENGTH (FT)	OPERATING SPEED (FT/SEC)	CARRYING CAPACITY (PASS/HR)
CITIES: DOMESTIC			
AKRON	600-3600	1.5-15	5000
ATLANTA	1300		
BOSTON	1300-5600	6.5-15	3000-14000
CHICAGO			
CLEVELAND			
COLUMBUS	2800		5000
HARTFORD			
HOUSTON	2500	1.5-15	4000-6000
INGLEWOOD			
LAS VEGAS			
LOS ANGELES			
MIAMI	1300	6.0	
MINNEAPOLIS			
NEW YORK	1100	1.5-15	10000
PHILADELPHIA			
PITTSBURGH			
PORTLAND			
RESTON			
SAN DIEGO			
SAN FRANCISCO	600-1300	1.5-9	
SAN JOSE	4000	[illegible]	[illegible]
SEATTLE			
ST. LOUIS			
WASHINGTON			
CITIES: FOREIGN			
MANCHESTER, ENG.			
MONTREAL, CAN.			
MUNICH, GERMANY			
PARIS, FRANCE	600-2900	1.5-15	20000
OTTAWA, CAN.			
TORONTO, CAN.	13000		

SOURCE: PROCEEDINGS OF THE WORKSHOP ON MOVING WAY TRANSPORTATION SYSTEMS, HELD AT BOSTON, MASSACHUSETTS, NOVEMBER, 1973

APPENDIX G

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