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A Shuttle Bus for the University of Central Florida

Maryam Hosseini-Kargar
University of Central Florida

A SHUTTLE BUS FOR THE
UNIVERSITY OF CENTRAL FLORIDA

BY

MARYAM HOSSEINI-KARGAR

RESEARCH REPORT

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ABSTRACT

The University of Central Florida, with an enrollment of approximately 16,000 students, is being faced with parking, traffic and transportation problems. The University of Central Florida (UCF) is a commuter campus, with over 90% of the students arriving by automobile. Parking spaces cost over $800/space, and funding to build new spaces is scarce. Existing lots on the perimeter of the UCF campus offer a potential advantage to park and ride services or a shuttle serve around UCF.

Research conducted for this paper evaluated the usage of a shuttle bus system around the UCF campus. The primary purpose of the shuttle is to move people around the campus, similar to the shuttle used by Disney. This is a benefit primarily to the users, but it is also an asset to the whole campus, especially since it increases the general mobility of the University population and its accessibility to various locations and activities.

The size of shuttle travel area around the campus, routes that would serve all major areas of the campus and cost of the shuttle bus are the major points evaluated in this research report. The methodology included in this study references the Urban Transportation Planning Process (UTPP), which consists of four sub-models: (1) trip generation, (2) trip distribution, (3) modal split and (4) traffic assignment.

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The author wishes to dedicate this paper to her parents, Ali and Parivash Hosseini-Kargar, for their encouragement and love throughout her education.

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The conclusions of this research report are the opinions of the author, and not those of the supporting committee or the chairman.

CHAPTER I

PROBLEM STATEMENT

The University of Central Florida (UCF) was founded in 1963 under the name Florida Technological University. It is one of the ten state universities in Florida. Classes began in October 1968, with an enrollment of 1,891 students. In 1979, there were 12,000 students attending the University. In 1984, the student count reached 15,860 students (Farah 1985). As the student enrollment increases, the University will face parking, traffic and transportation problems. The University will no longer be able to provide adequate parking in all areas of the campus close to destinations of the students and staff.

At the present time, the campus parking system consists of 5,100 parking spaces, 900 of which are reserved for faculty and staff. These parking spaces are serving 12,000 student cars and 1,600 faculty-staff automobiles, so the inequity of supply and demand is obvious.

Research Objective

With the growth that the University is facing, a parking problem is going to be a major problem. A survey, conducted by Waddah Farah (1985), showed that students arrive at their classes 15 minutes before the class began. It is clear that the students would want to park as close as possible to their destination, and with the parking shortage, this would create a problem. Therefore, we are facing a problem of moving students to and around the campus. With the growth that the University is expecting, finding a solution to this problem is necessary.

This report considers the ability of a rubber-tire shuttle system to help movement of students and faculty around the campus. In doing so, an Urban Transportation Planning Process (UTPP) model was utilized. This process will be explained in Chapter III.

The primary purpose of the shuttle bus is to move people around the campus, and especially to aid in making long trips and trips in inclement weather. This is a benefit primarily to the user, but it is also an asset to the whole campus, as it increases the general mobility of the University population and its accessibility to various locations and activities. This report evaluates the probability of running a shuttle bus system on the UCF campus.

CHAPTER II

METHODOLOGY

The methodology that was used for this report is the Urban Transportation Planning Process (UTPP). The UTPP has been used for urban areas. In this report, the University was considered as the urban area, and the model was built for the University. The UTPP includes four sub-models: (1) trip generation, (2) trip distribution, (3) modal split and (4) traffic assignment (see Figure 1). The planning area is subdivided into traffic analysis zones. Zones are typically made by housing, airport, etc. For the purpose of this research report, each building and parking lot has been considered as an individual zone. Trip generation provides the number of trips to and from each zone in the planning area. Trip distribution estimates the number of trip interchanges between zones. Modal split estimates the number of trip interchanges between zones. Modal split estimates the number of travelers that would use the different modes of transportation (auto, transit, walking or bicycles). Lastly, the traffic assignment determines the paths taken from each zone to all other zones. A listing of these zones is given in Table 1.

Types of Trips

Figure 2 shows the three types of trips: (1) internal-internal (trips which have origins and destinations inside the planning area),

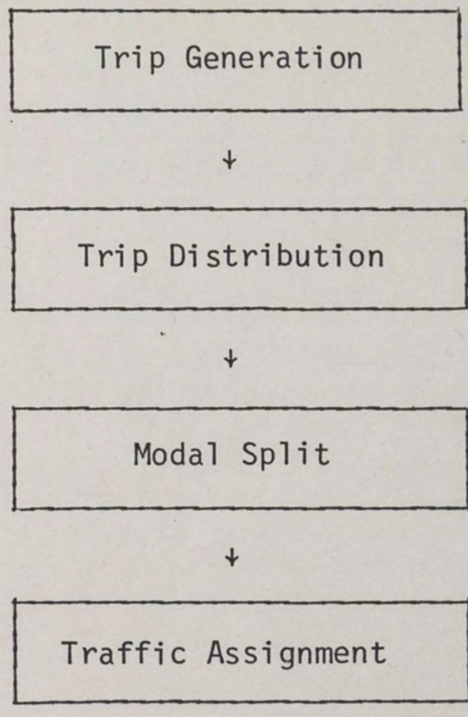


Figure 1. The Four Basic Models of the Urban Transportation Planning Process (UTPP).

TABLE 1

LIST OF ZONES

ZONE #	NAME OF ZONE
1	Portable Classroom (PC) #2
2	Portable Classroom (PC) #1
3	Computer Center
4	Education Building
5	Biology Building
6	Fine Arts Building
7	Phillips Hall
8	Engineering Building
9	Theater
10	Chemistry Building
11	Administration Building
12	1W-6W Parking Lot
13	1-2 Parking Lot
14	6-7 Parking Lot
15	8 Parking Lot
16	9 Parking Lot
17	4 Parking Lot
18	East Parking Lot
19	Library
20	Bookstore
21	Recreational Center
22	Student Center

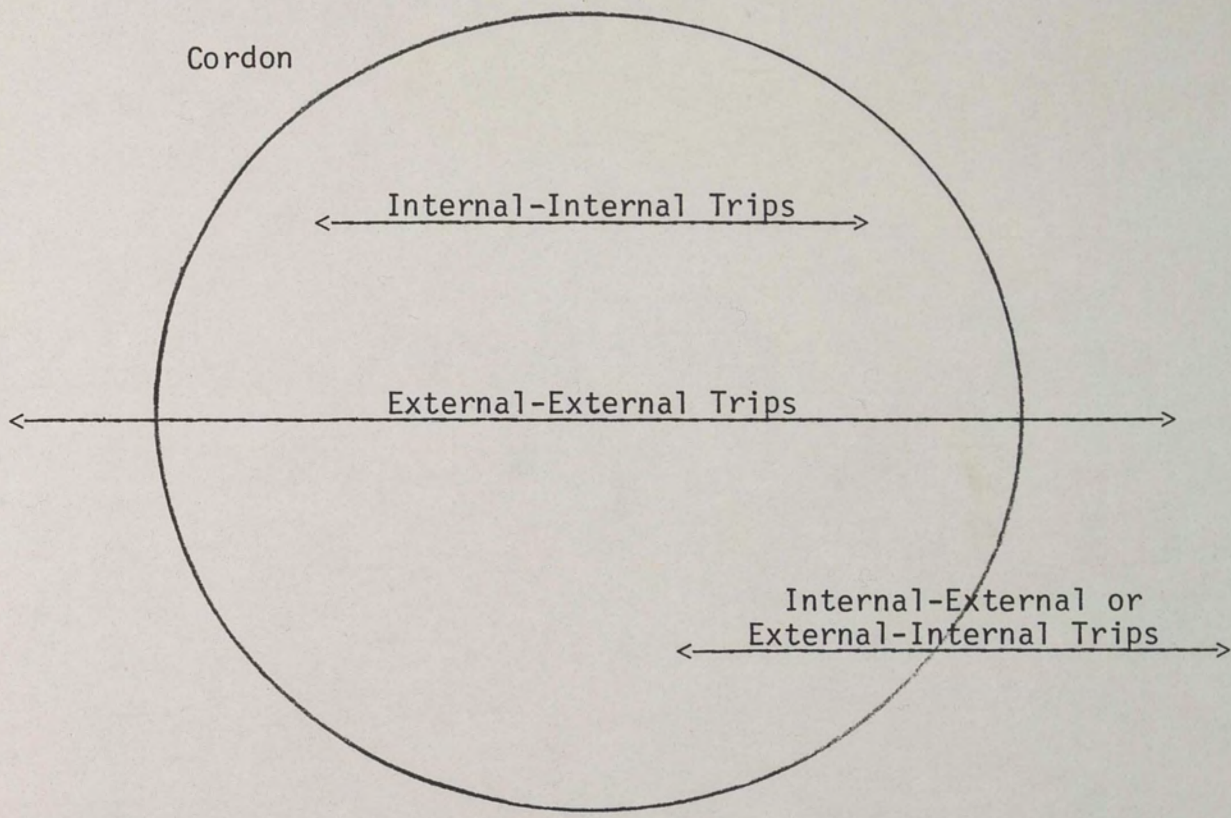


Figure 2. Types of Trips.

(2) external-external (trips which have origins and destinations outside the planning area) and (3) internal-external or external-internal (trips which have origins inside the planning area and destinations outside the planning area or vice-versa).

There are some assumptions that must be made when considering the size of the shuttle bus, the trips and the routes. These are:

1. According to the UCF Physical Plant, all the radials (sidewalks) are built to handle moving vehicles. The radials have the following dimensions: 6" lime rock base, 1" asphalt, 10" stabilizers, and 6" reinforced concrete (for a total of 17").

2. The routes that the shuttle will cover are 16' wide, which is large enough for the shuttle and for pedestrians to pass safely.

3. The trips would take the minimum path route.

4. The external-internal (internal-external) trips are the trips from the parking lots to campus or vice-versa. Internal-internal trips are trips between the buildings (class to class). There should not be any external-external trips (parking lot to parking lot).

5. The primary purpose of the shuttle bus is to get students from the parking lot to class, and then to another class or back to the parking lot.

CHAPTER III

DESCRIPTION OF THE CAMPUS SHUTTLE BUS SYSTEM

The bus system can be entirely student-run, with student bus drivers and student supervisors. This would create more jobs for UCF students. The buses would operate between the hours of 7:30 a.m. and 5:30 p.m., Monday through Friday. They would follow a route that served all major areas of the campus, as well as the parking lots (see Figure 3). For a shuttle bus to operate successfully, it must not have any fare to the users. The cost can be incorporated into student fees, and the faculty/staff could be charged on a yearly basis.

The potential routes that the shuttle takes are from parking lot 1W and 3W to building 18 and building 19, to the administration building, and then going to buildings 13, 12, 6 and 5. The final stop would be at the east parking lot. Then, the shuttle bus would start back and serve this same route, with the last stop being at parking lots 1W and 3W. Other possible routes that the shuttle could take would be to start from the east parking lot, to parking lot 4, then to the student center, administration building, library, buildings 18 and 19 and finally parking lots 1W and 2W.

Trip Generation

Trip generation provides the number of trips to (attraction, A) and from (production, P) various activities (also called zones).

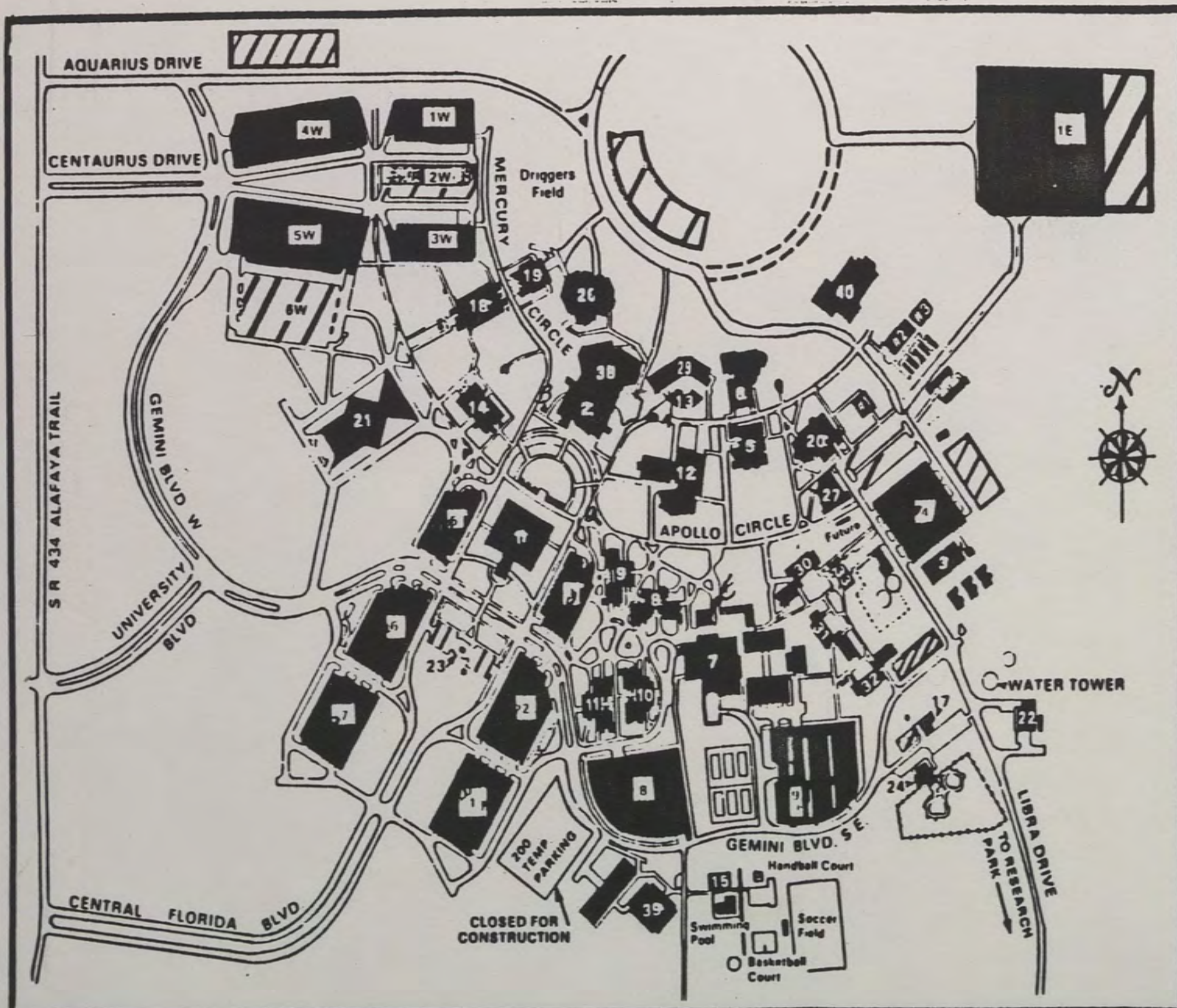


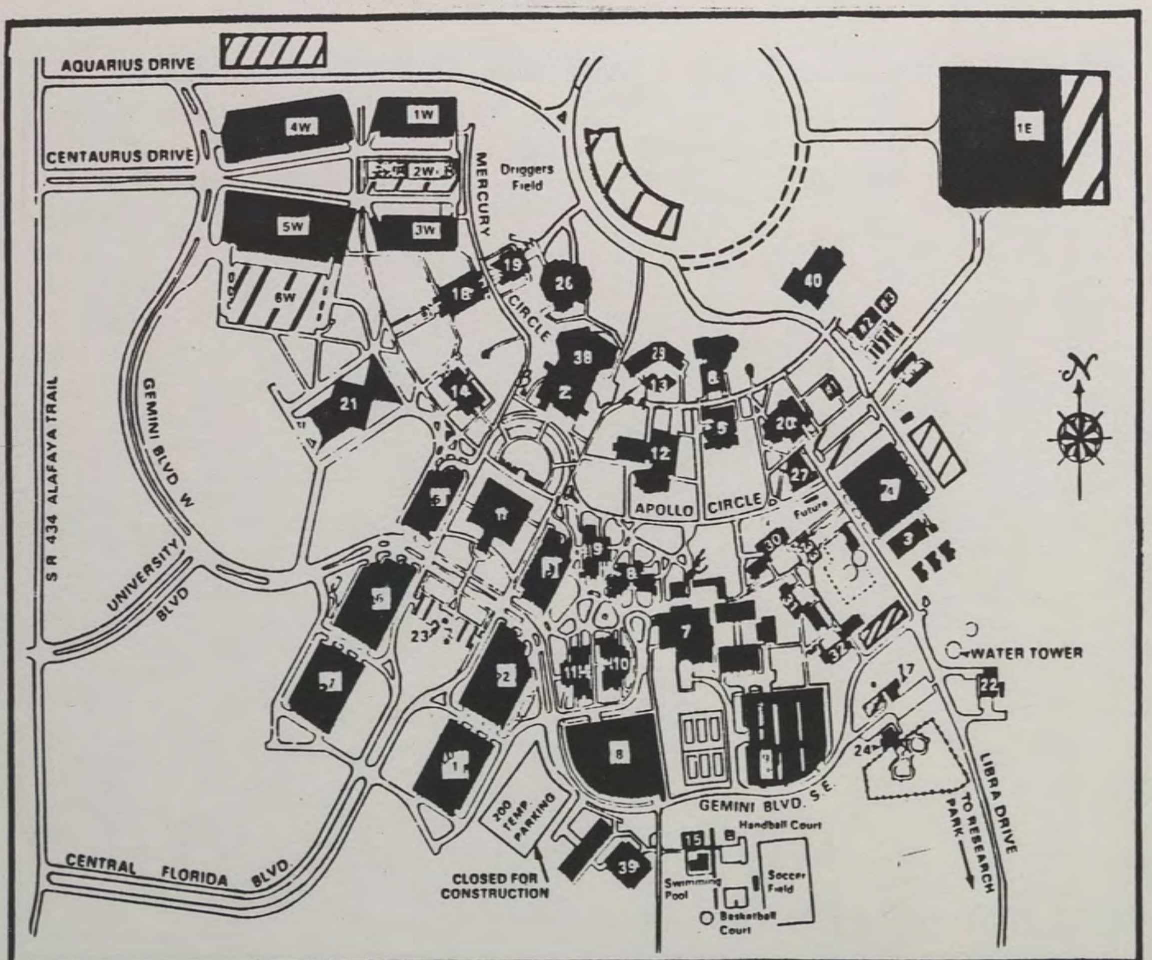
Figure 3. Campus Map (University of Central Florida 1984).

Figure 4 shows the various zones on the UCF campus. In this report, each parking lot and building is considered one individual zone.

A campus summary has been done by the University which includes the number of students for every hour and each building between the hours of 7:00 a.m. and 10:00 p.m. The campus summary was done for every class (including labs) to get the maximum number of students. The labs were included with the classes.

UCF has continuous peak hours from 9:00 a.m. to 3:00 p.m. For this report, the peak hour will be 12:00 noon to 1:00 p.m. and the peak day will be Wednesday.

For the P (production) and A (attraction) of every building, the campus summary was used. For production, the number of students that leave the classes at 12:00 noon (11:00 a.m. to 12:00 noon classes) was used. For attraction, the number of students that enter the classes at 12:00 noon (for 12:00 noon to 1:00 p.m. classes) was used. A list of the P and A values for buildings and parking lots is shown in Table 2. For special zones (i.e., the library, administration building, bookstore, recreation center or student center). A physical count has been done for special zones, like the Library, Bookstore, Recreational Services and the Student Center, on the peak day and at the peak hour. Also, the author counted the cars going to and coming from the parking lots for the peak hour. Table 3 shows the enrollments for the classes and labs for each class hour on Wednesdays.



Legend:

1	Administration Building	7	Student Center	18	Fine Arts Building
2	Library	12	Engineering Building	20	Biology Building
5	Chemistry Building	13	Computer Center	40	CEBA Building
6	Theater				

Figure 4. Campus Map Showing Zones (University of Central Florida 1984).

TABLE 2

ZONAL PRODUCTION AND ATTRACTION

ZONE	BUILDING NAME OR PARKING LOT NUMBER	PRODUCTION, P	ATTRACTION, A
1	PC#2	325	262
2	PC#1	153	171
3	Computer Center	57	55
4	Education	423	407
5	Biology	202	184
6	Fine Arts	304	220
7	Phillips Hall	471	498
8	Engineering	1001	1178
9	Theater	250	303
10	Chemistry	92	70
11	Administration	320	370
12	1W-6W	289	296
13	1-2	95	100
14	6-7	98	97
15	8	55	50
16	9	65	58
17	4	35	38
18	East	265	207
19	Library	180	438
20	Bookstore	168	180
21	Rec. Services	30	30
22	Student Center	450	538

SOURCE: University of Central Florida 1984

TABLE 3

CLASS ENROLLMENTS

CLASS HOUR	CLASS ENROLLMENT	LAB ENROLLMENT	CLASS AND LAB ENROLLMENT
07:00-08:00 a.m.	33	0	33
08:00-09:00 a.m.	1741	43	1784
09:00-10:00 a.m.	2438	265	2703
10:00-11:00 a.m.	2530	339	2869
11:00-12:00 noon	2653	323	2976
12:00-01:00 p.m.	2776	291	3067
01:00-02:00 p.m.	2361	406	2767
02:00-03:00 p.m.	2246	307	2553
03:00-04:00 p.m.	1406	279	1685
04:00-05:00 p.m.	1151	249	1400
05:00-06:00 p.m.	637	229	866
06:00-07:00 p.m.	1642	217	1859
07:00-08:00 p.m.	1712	221	1933
08:00-09:00 p.m.	1097	97	1194
09:00-10:00 p.m.	252	44	296

SOURCE: University of Central Florida 1984

Trip Distribution

Trip distribution is a significant element of the planning process because it is the trip interchanges that eventually have to be accommodated by a transportation system. Trip distribution is the process by which trips from one area are connected with trips from another area, thereby linking origins and destinations or productions and attractions. Figure 5 has a summary flow chart of the trip distribution procedure.

To get the trips between zones, the trips (P and A) from trip generation were used. For trip distribution, the gravity model was used (Transportation Research Board 1978).

The gravity model was developed from Newton's laws of universal gravitation and was used for distribution of trips (internal-internal and external-internal) (Leftwich 1982). This technique relies on the hypothesis that the trips produced at an origin are distributed to alternative destinations in direct proportion to the relative attractions of the various destinations and inversely proportional to a measure of the relative spatial separation between the origin and the various destinations.

In this report, the gravity model was made for internal-internal and external-internal trips.

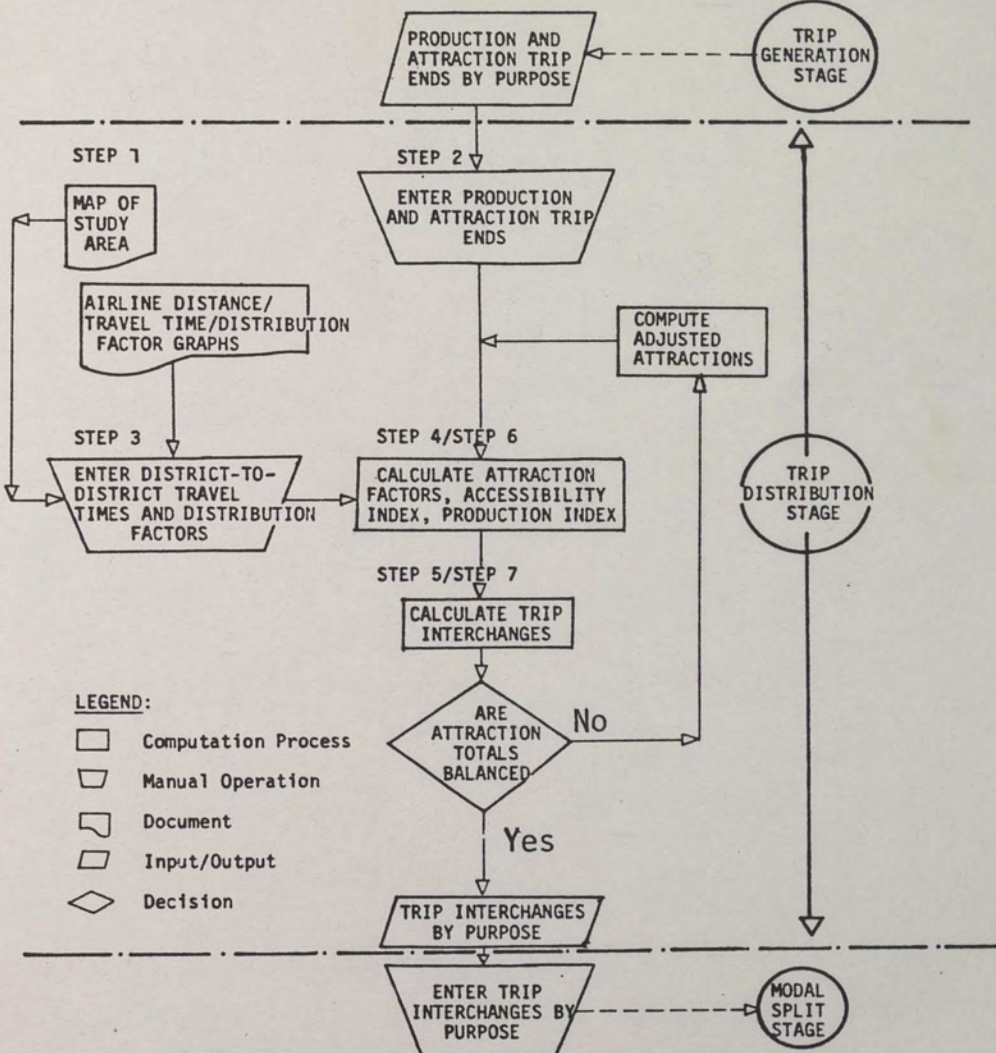


Figure 5. Summary Flow Chart of the Trip Distribution Procedure (Transportation Research Board 1978).

Theory of the Gravity Model

The gravity model can be mathematically expressed as (Transportation Research Board 1978):

$$Tij = Pi \frac{Aj\ Fij\ Kij}{\sum_{j=1}^{n} Aj\ Fij\ Kij}$$

$$Fij = f(tij)$$

where:

- Tij = trips produced in analysis area i and attracted at analysis area j
- Pi = total trip production at i
- Aj = total trip attraction at j
- Fij = friction factor for trip interchange ij
- Kij = socioeconomic adjustment factor for interchange ij (if necessary)
- tij = travel time (or impedance) for interchange ij
- i = origin analysis area number (i = 1, 2, ..., n)
- j = destination analysis area number (j = 1, 2, ..., n)
- n = number of analysis area (number of zones)

Mathematically, the gravity model is formulated so that a production balance is maintained. In other words, the production total for each zone, as calculated from the model, was equal to the input productions. However, the attraction totals for each analysis area output from the model will not necessarily match the desired input values. The production for each zone is exact, whereas the attraction is not exact. To attain an acceptable attraction balance, an iterative process is employed to adjust the calculated trip interchanges. After each application (iteration) of the gravity model, the adjusted attraction total (for each analysis area) to be used for the next iteration are calculated according to the following formula (Transportation Research Board 1978):

$$Aj^{q} = (Aj^{q-1}) \left(\frac{Aj}{Cj^{q-1}}\right)$$

where:

Aj^{q} = adjusted attraction factor for attraction analysis area j, iteration q

Aj^{q-1} = Aj when q-1

Cj^{q-1} = attraction total for analysis area j, resulting from the application of the gravity model during iteration q-1

Aj = original and desired attraction total for attraction analysis area j; this is the value developed from the trip generation step

j = attraction analysis area (j = 1, 2, ..., n)

n = number of analysis areas

q = iteration number (1 = 1, 2, ..., n)

The distribution factor (friction factor) for the urbanized area for four population groups and for three trip purposes are: home base work (HBW), home base non-work (HBNW) and non-home base (NHB). The urbanized area population groups for each distribution factor are as follows:

50,000 to 100,000 population

100,000 to 250,000 population

250,000 to 750,000 population

750,000 to 2,000,000 population

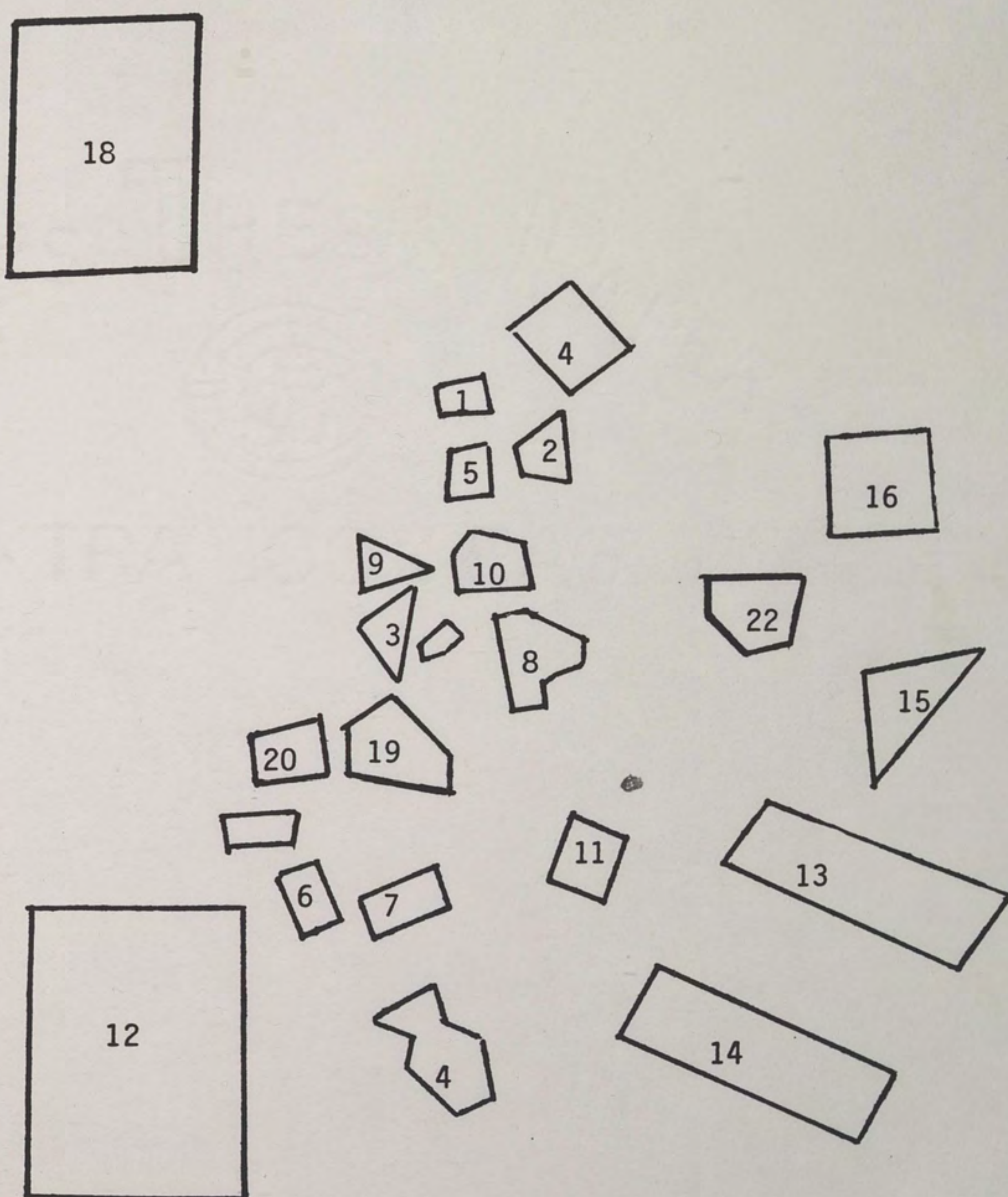
Input Requirements

The following input information is necessary before proceeding with the distribution process:

1. A map of the study area showing the zones and centroids (shown in Figure 6)
2. Production and attraction trip ends by analysis area (in this case, the trip purpose is NHB); these figures are output from the trip generation step
3. Travel time (tij) and distribution factor (Fij) for one zone to another zone would be entered

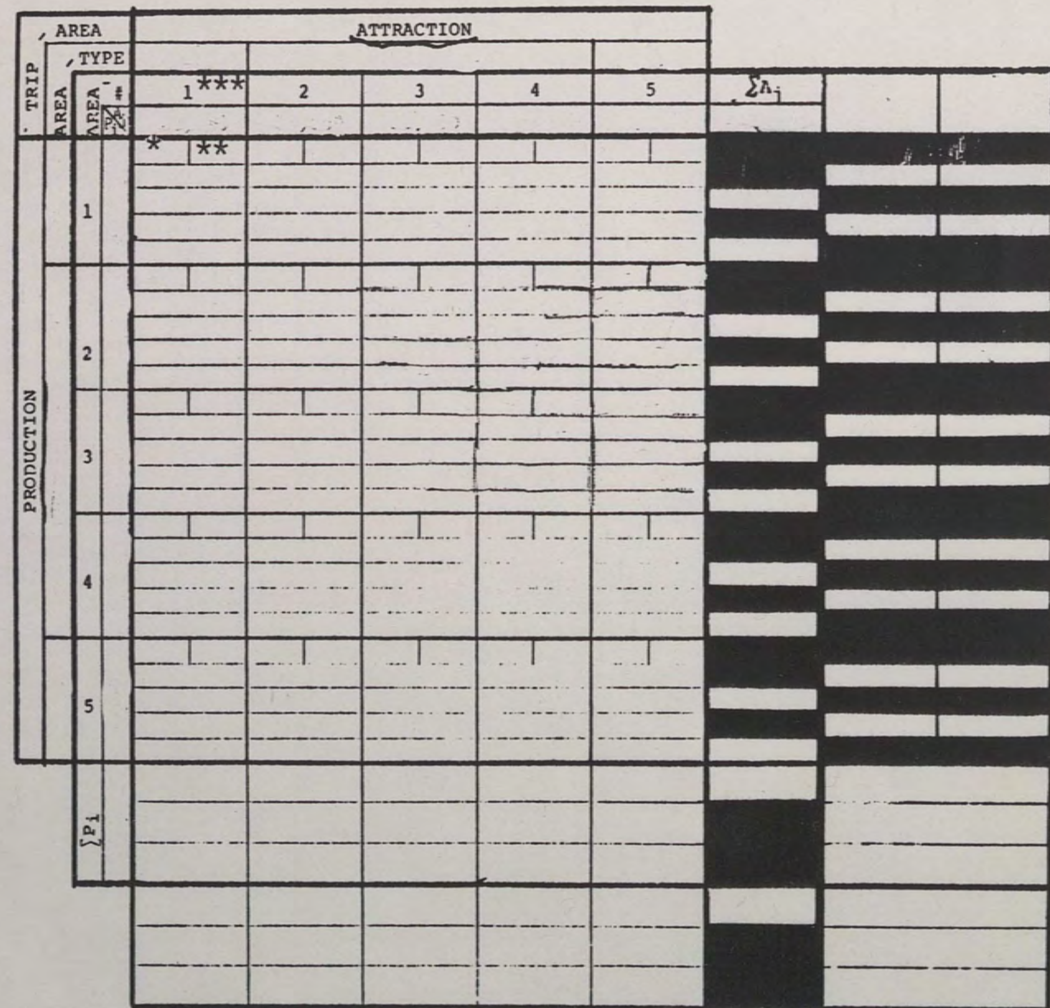
This matrix is triangular; that is, it is assumed that the travel time from zone i to zone j is the same from zone j to zone i. An example of this matrix is shown in Figure 7. It should be noted that the gravity model analysis in this report consisted of a 22 by 22 matrix.

Because the gravity model for the 22 zones is time consuming if computed manually, a computerized gravity model was utilized (U.S. Department of Transportation 1984). Figure 6 is a map of the study area with the 22 zones and centroids. Walking time between two zones has been measured and, based on this measurement, the travel time for the 22 zones has been measured from the map of the study area.



NOTE: The squares indicate the zone and the number inside the square indicates the zone number.

Figure 6. Campus Map Showing Zones and Centroids (University of Central Florida 1984).



* Travel Time ** Friction Factor *** Zone Number (1-22)

Figure 7. Sample Production and Attraction Matrix (Transportation Research Board 1978).

For friction factor, table values provided by a computer program were used. In this study, the non-home base trip (NHB) was used.

Functions for Trip Distribution

Production and attraction (P and A) from the trip generation are:

1. interzonal time
2. intrazonal time
3. F-factor by purpose
4. gravity model formulation

Table 4 shows the production and attraction values for the 22 zones. Table 4 also has the interzonal times that have been measured from the University map (scale: 1" = 200'). The intrazonal time for every zone has been measured by the surrounding zone. The formula is (Transportation Research Board 1978):

$$\text{intrazonal time zone } i = \frac{\text{average travel time of surrounding zones of zone } i}{2}$$

Table 5 shows the surrounding zones for every zone. The F-factor has been used from a default F-factor table by travel time iteration used for the gravity model. Table 6 is a computer output that shows the trip interchanges between the zones. For example, in Table 6, trips from zone 1 (origin zone) to zone 22 (destination zone) equal 31 trips.

TABLE 4

TRAVEL TIME MATRIX
(in minutes)

PRODUCTION* \ ATTRACTION*	PC#2 1 262	PC#1 2 171	C.C. 3 55	Edu. 4 407	Bio. 5 184	F.A. 6 220	P.H. 7 498	Eng. 8 1178	Th. 9 303	Chem. 10 70	Adm. 11 177	1W-6W 12 296	1-2 13 100	6-7 14 97	8 15 50	9 16 58	4 17 38	East 18 207	Lib. 19 438	B.S. 20 180	R.S. 21 30	S.C. 22 638
PC#2 1 305	-	1.54	4.38	10.83	1.58	8.33	8.46	5.21	3.33	3.83	8.42	10.75	11.25	12.50	9.79	8.08	2.83	2.83	6.08	6.25	10.42	3.33
PC#1 2 153	1.54	-	3.67	10.17	1.13	8.08	7.79	4.08	2.67	2.79	7.50	10.58	10.00	11.42	8.63	6.75	1.67	4.50	5.42	6.04	8.83	1.79
C.C. 3 57	4.83	3.67	-	6.71	3.08	4.50	4.25	1.25	1.25	1.67	4.33	7.08	7.83	8.42	7.50	7.29	4.83	6.88	1.88	2.71	8.67	3.33
Edu. 4 423	10.83	10.17	6.71	-	10.21	3.21	2.33	6.42	8.54	7.71	3.83	4.00	6.67	4.50	8.63	11.08	10.92	12.75	4.79	5.13	11.17	9.17
Bio. 5 202	1.58	1.13	3.08	10.21	-	7.38	6.96	3.13	2.08	1.67	6.46	10.00	8.92	10.42	7.33	6.00	1.92	5.42	4.58	5.50	8.13	1.04
F.A. 6 304	8.33	8.08	4.50	3.21	7.38	-	1.88	5.21	5.54	5.96	4.25	2.75	8.17	7.08	9.38	10.67	9.17	10.04	2.92	1.25	11.46	7.67
P.H. 7 471	8.46	7.79	4.25	2.33	6.96	1.88	-	4.38	5.75	5.42	2.42	4.33	6.25	5.33	7.67	9.33	8.63	10.75	2.50	3.21	9.79	7.00
Eng. 8 1001	5.21	4.08	1.25	6.42	3.13	5.21	4.38	-	2.33	1.13	3.42	7.83	6.29	7.42	5.71	5.83	4.58	8.17	2.38	3.96	7.42	2.83
Th. 9 250	3.33	2.67	1.25	8.54	2.08	5.54	5.75	2.33	-	1.33	5.29	8.08	8.54	9.42	7.71	7.17	3.92	5.83	2.92	3.54	9.00	2.75
Chem. 10 92	3.83	2.79	1.67	7.71	1.67	5.96	5.42	1.13	1.33	-	4.88	8.75	7.63	8.83	6.38	5.88	3.33	6.67	3.25	4.33	7.67	1.79
Adm. 11 191	8.42	7.50	4.33	3.83	6.46	4.25	2.42	3.42	5.29	4.88	-	6.58	4.17	4.17	5.21	7.17	7.71	11.46	3.17	4.67	7.42	6.04
1W-6W 12 289	10.75	10.58	7.08	4.00	10.00	2.75	4.33	7.83	8.08	8.75	6.58	-	0	0	0	0	0	0	5.83	4.83	13.96	10.21
1-2 13 95	11.25	10.00	7.83	6.67	8.92	8.17	6.25	6.29	8.54	7.63	4.17	0	-	0	0	0	0	0	7.08	8.58	5.21	8.33
6-7 14 98	12.50	11.42	8.42	4.50	10.42	7.08	5.33	7.42	9.42	8.83	4.17	0	0	-	0	0	0	0	7.21	8.21	8.50	9.79
8 15 55	9.79	8.63	7.50	8.63	7.33	9.38	7.67	5.71	7.71	6.38	5.21	0	0	0	-	0	0	0	7.38	9.04	2.42	6.46
9 16 65	8.08	6.75	7.29	11.08	6.00	10.67	9.33	5.83	7.17	5.88	7.17	0	0	0	0	-	0	0	8.21	9.67	2.50	4.79
4 17 35	2.83	1.67	4.83	10.92	1.92	9.17	8.63	4.58	3.92	3.33	7.71	0	0	0	0	0	-	0	6.38	7.29	7.71	1.67
East 18 265	2.83	4.50	6.88	12.75	5.42	10.04	10.75	8.17	5.83	6.67	11.46	0	0	0	0	0	0	-	8.33	7.92	13.12	6.25
Lib. 19 180	6.08	5.42	1.88	4.79	4.58	2.92	2.50	2.38	2.92	3.25	3.17	5.83	7.08	7.21	1.38	8.21	6.38	8.33	-	1.75	9.17	4.79
B.S. 20 168	6.85	6.04	2.71	5.13	5.50	1.25	3.21	3.96	3.54	4.33	4.67	4.83	8.58	8.21	9.04	9.67	7.29	7.92	1.75	-	10.83	5.83
R.S. 21 30	10.42	8.83	8.67	11.17	8.13	11.46	9.79	7.42	9.00	7.67	7.42	13.96	5.21	8.50	2.42	2.50	7.71	13.12	9.17	10.83	-	7.08
S.C. 22 450	3.33	1.79	3.33	9.17	1.04	7.67	7.00	2.83	2.75	1.79	6.04	10.21	8.33	9.79	6.46	4.79	1.67	6.25	4.79	5.83	7.08	-

*Explanation of Terms: PC#2 - Name of Building
1 - Zone Number
262 - Attraction or Production

NOTE: Travel times to and from zones are the the same. Example:
1 to 4 travel time = 10.83 min.
4 to 1 travel time = 10.83 min.

TABLE 5

SURROUNDING ZONES USED TO
DETERMINE INTRAZONAL TIMES

ZONE	SURROUNDING ZONE
1	2, 5
2	1, 5, 4, 22
3	8, 9, 10
4	6, 7
5	1, 2, 22, 17
6	7, 20
7	4, 6
8	3, 10
9	4, 10
10	3, 5, 8
11	7, 8
12	4, 6
13	11, 21
14	4, 11
15	11, 21
16	21
17	2, 5, 22
18	13, 2
19	3, 8, 20
20	6, 19
21	15, 16
22	2, 5, 16

TABLE 6

ZONAL TRIP INTERCHANGES

ORIGIN ZONE 1

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		53	25	3	3	26	6	4	46	25
10	3	3	5	2	1	2	2	5	71	7
20	4	0	31							

ORIGIN ZONE 2

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		16	15	2	1	11	1	3	20	11
10	2	2	2	1	1	1	2	3	16	4
20	2	0	37							

ORIGIN ZONE 3

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		1	1	1	1	2	1	2	20	6
10	1	2	1	1	0	1	0	1	1	8
20	2	0	4							

ORIGIN ZONE 4

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		2	2	1	114	2	19	62	31	4
10	2	28	63	12	25	2	2	1	4	28
20	12	1	6							

ORIGIN ZONE 5

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		21	14	1	2	15	2	4	33	14
10	5	4	2	2	1	2	2	5	13	9
20	3	1	47							

ORIGIN ZONE 6

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		3	1	2	23	3	29	63	26	7
10	1	12	56	3	5	1	1	1	4	31
20	25	0	7							

ORIGIN ZONE 7

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		3	3	3	55	4	44	96	61	11
10	2	37	42	11	13	4	2	1	6	48
20	13	1	11							

ORIGIN ZONE 8

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		25	16	17	21	22	15	47	385	58
10	23	42	26	18	13	13	14	6	18	83
20	24	3	112							

ORIGIN ZONE 9

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		14	8	5	3	9	4	8	59	39
10	7	5	4	3	2	2	2	2	14	23
20	6	1	30							

ORIGIN ZONE 10

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		3	3	2	2	6	1	3	37	10
10	3	3	1	2	0	1	2	0	4	5
20	2	0	2							

ORIGIN ZONE 11

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		2	3	2	27	4	9	42	61	9
10	2	52	14	19	16	6	3	1	4	24
20	8	1	11							

TABLE 6 -- CONTINUED

ORIGIN ZONE 12

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		3	1	2	47	2	34	36	28	5
10	1	89	0	0	0	0	0	0	0	21
20	14	0	6							

ORIGIN ZONE 13

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		2	1	1	10	2	2	10	23	3
10	1	7	15	0	0	0	0	0	0	8
20	1	3	6							

ORIGIN ZONE 14

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		1	1	0	24	1	4	15	18	2
10	1	16	0	0	0	0	0	0	0	7
20	2	1	5							

ORIGIN ZONE 15

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		1	1	0	3	1	1	4	18	2
10	1	8	0	0	0	0	0	0	0	4
20	1	4	6							

ORIGIN ZONE 16

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		2	2	0	2	2	1	2	20	3
10	1	6	0	0	0	0	0	0	0	2
20	1	5	16							

ORIGIN ZONE 17

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		3	3	1	0	4	0	1	6	2
10	1	0	0	0	0	0	0	0	1	1
20	0	0	12							

ORIGIN ZONE 18

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		70	23	3	5	16	4	9	32	26
10	4	16	0	0	1	0	0	0	0	13
20	9	0	34							

ORIGIN ZONE 19

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		2	2	4	9	4	8	19	43	11
10	2	1	9	3	3	1	1	0	4	30
20	13	0	11							

ORIGIN ZONE 20

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		2	1	2	10	2	15	12	27	8
10	1	8	15	1	2	1	0	1	5	30
20	18	0	7							

ORIGIN ZONE 21

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		0	1	0	0	1	0	1	4	0
10	0	4	0	3	1	4	4	1	0	1
20	0	3	2							

ORIGIN ZONE 22

DEST ZONE	0	1	2	3	4	5	6	7	8	9
00		17	31	3	5	33	4	9	114	31
10	1	6	6	5	3	4	12	11	19	22
20	6	2	106							

Modal Split

The author has conducted a survey that shows 12% of the pedestrians would ride a shuttle bus, if available, for external-internal or internal-internal trips. Due to the large commuter traffic coming to UCF (over 90%), it was felt that a 12% share is a reasonable value.

Traffic Assignment and Calibration

Three locations were considered in the traffic assignment. These included the most crowded routes (which covered the most crowded buildings) and had the highest traffic counts (pedestrian counts). These locations are shown below and are indicated on the map in Figure 8.

Location	Pedestrian Counts
A (in front of the Engineering building and the Computer Center)	1078
B (between the Library and Phillips Hall)	710
C (in front of the Student Center, across from Apollo Circle)	820

These volumes are matched with the output from the traffic assignment (synthetic volumes from the model). If the output from the traffic assignment did not match the pedestrian counts, then the model was adjusted to reflect the actual situation. Now that the trip interchanges between zones have been determined, we determine the routes connecting the zones. It is a rule of thumb that people

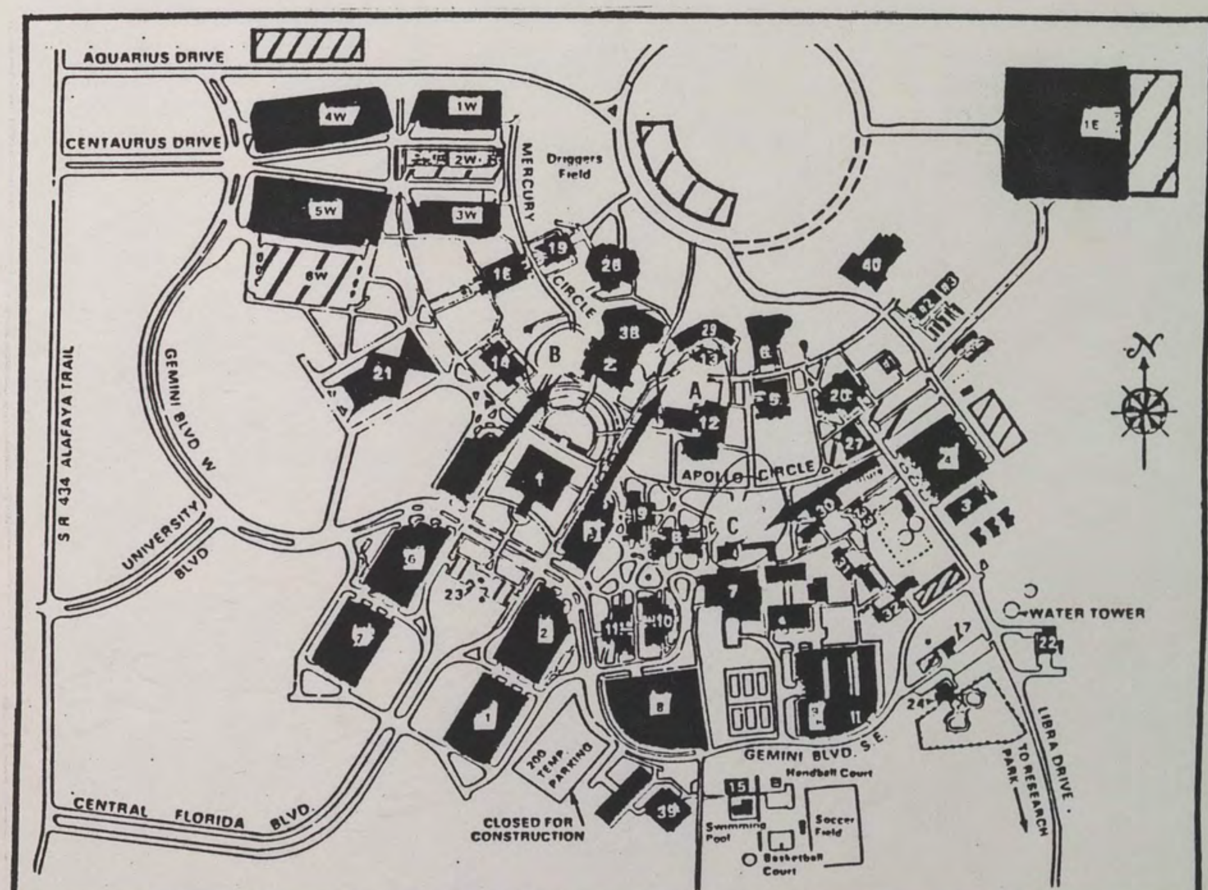


Figure 8. Campus Map with Pedestrian Counts
(University of Central Florida 1984).

would walk one-fourth of a mile to a bus stop location. Therefore, we can assume that students will walk one-fourth of a mile from the parking lots. To get the trips at points selected, all the trip interchanges that had to pass the special point were considered. It is assumed that all the trips take the minimum path, and the trips with one-fourth of a mile or less were not considered in the volume of the special point. The calculation of the counts will be shown in another section of this report.

The trip interchanges between the buildings (zones) from the gravity model were done by a computer program. Then, for every one of the three locations, the trips that would pass that point must be considered. The trips that would be less than one-fourth of a mile were not considered, assuming that people would walk one-fourth of a mile. Every individual zone was considered in its relationship with the other zones. Other considerations were if the trips would be more than one-fourth of a mile and if the trips would pass the special point (assuming the trips would take the minimum paths). The calculations for modeling the flow of pedestrians on the campus for these three locations follow.

Point A

Point A is between the Computer Center and the Engineering Building.

(the trips going from each zone to the Computer Center) + (10) + zone 6 to (PC#2, PC#1, 5, 8, 9, 10, 22, 17, 18) + zone 4 to (PC#2, PC#1, 5, 9, 10) + zone 1 to (4, 6, 7, 8, 11, 19, 20) + zone 2 (4, 6, 7, 8, 11, 19, 20, 12, 13, 14) + zone 5 to (21, 6, 7, 8, 11, 19, 20, 12, 13, 14) + zone 7 to (1, 2, 5, 9, 10, 17, 18) + zone 8 (6, 20, 12, 17, 18) + zone 9 (4, 6, 7, 19, 20, 12, 13, 14) + zone 10 to (4, 6, 7, 8, 11, 12, 19, 20) + zone 11 to (1, 2, 5, 9, 10, 4, 18, 20) + zone 12 to (1, 2, 5, 9, 10) + zone 13 to (1, 2, 5, 9, 10, 20) + zone 14 to (1, 2, 5, 8, 9, 10, 20) + zone 15 to (20) + zone 16 to (20) + zone 17 to (4, 6, 7, 8, 11, 19) + zone 18 to (4, 6, 7, 8, 11, 19, 20) + zone 19 to (1, 2, 5, 9, 10, 17, 18, 20) + zone 20 to (1, 2, 5, 8, 9, 10, 11, 17, 18, 19, 21, 22) + zone 21 to (20) + zone 22 to (20)

\- - - - - -

167 + (26 + 7 + 7 + 7) + (12 + 5) + (53 + 3 + 11 + 8) + (33 + 4) + (45 + 12 + 5) + (23 + 7 + 2) + (15 + 24 + 26 + 24) + (16 + 23 + 6 + 5) + (43 + 4 + 7) + (47 + 12) + (12) + (10) + (26) + (2) + (1) + (8) + (66) + (21 + 17) + (85 + 7) + (0) + 6 = 948 computed trips

ACTUAL COUNTED TRIPS ARE: 1078

Point B

Point B is between Phillips Hall, the Library and the Fine Arts Building.

zone 1 to (4, 7) + zone 2 to (4, 7) + zone 3 to (4, 7) + zone 4 to (4, 1, 2, 3, 5, 6, 8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 22) + zone 5 to (4, 7) + zone 6 to (4, 7, 11, 14, 19) + zone 7 to (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 17, 18, 19, 20) + zone 8 to (4, 6, 7) + zone 9 to (4, 6, 7) + zone 10 to (4, 6, 7) + zone 11 to (6, 12, 19, 20) + zone 12 to (7, 11, 19) + zone 13 to (6) + zone 14 to (1, 2, 3, 5, 6, 8, 9, 10, 19, 20) + zone 15 to (7) + zone 16 to (7) + zone 17 to (4, 7) + zone 18 to (4, 7) + zone 19 to (4, 6, 7, 11, 12, 20) + zone 20 to (4, 7, 14, 19) + zone 21 to (12, 6) + zone 22 to (6, 12)

\- - - - - -

(3 + 4) + (7) + (7) + (26 + 31 + 4 + 2 + 28 + 12 + 34 + 28 + 6) + (6) + (23 + 63 + 12 + 5 + 31) + (21 + 15 + 47) + (15) + (6) + (47 + 8) + (36 + 89 + 21) + (2) + (37) + (4) + (2) + (1) + (14) + (41 + 13) + (22 + 2 + 30) + (0) + (10) = 854 computed trips ACTUAL COUNTED TRIPS ARE: 700

Point C

Point C is the Student Center. All the zones going to the student center total 744 computed trips. COUNTED ACTUAL TRIPS ARE: 829

The following is a summary of the previous material.

Selected Points	Actual Pedestrian Count	Synthetic Volume (calculated)	Percent of Total
A	1078	948	87.9
B	710	854	120.3
C	820	744	90.7
	Σ 2608	Σ 2546	97.6

As can be seen, the calculated volumes are close to the pedestrian counts; therefore, there is no need to factor it up. Point A is chosen because it has the maximum count and the shuttle is designed for that point.

It is assumed that the shuttle coming from the parking lots already has passengers (external-internal trips). Therefore, the number of trips that are coming from the parking lots is calculated separately and then added to the number of people who ride the shuttle internally (internal-internal trips or internal-external trips). The author conducted a survey among UCF students. Four-hundred-thirty students were asked their opinion of the shuttle system. Twelve percent of the 430 said they would ride the shuttle. Then, the shuttle size was determined by subtracting 12%. From these trips, the trips coming from the parking lots are deducted.

$$1078 - (66 + 8 + 1 + 2 + 26 + 16 + 12) = 953 \text{ trips}$$

Of the 131 trips that are coming from the parking lot, some of the students are already on the shuttle. This number was used because it was assumed that the people will walk approximately one-fourth of a mile (or about 1323 feet). Therefore, every parking lot has been considered as follows:

Zone #	Parking Lot	# of Trips Passing Point A
12	1W-6W	12
13	1-2	10
14	6-7	26
15	8	2
16	9	1
17	4	(8-6)
18	East	(66-9)
		110

When the shuttle reaches the Point C, the trips that are within one-fourth of a mile walking distance are deducted.

953 - (167 - 3 - 4) - (47 - 3 - 1 - 3 - 7 - 1 - 4) - (17 - 2 - 2 - 2 - 4 - 2 - 1 - 4) - (75 - 3 - 4 - 4 - 3 - 7 - 4) - (37 - 1 - 1 - 2 - 4 - 2 - 2 - 1 - 1) - (62 - 2 - 2 - 4 - 4 - 2 - 2) - (30 - 3 - 3 - 4 - 1 - 6) - (89 - 26 - 18) - (50 - 3 - 4 - 3 - 2) - (54 - 2 - 1 - 1 - 2) - (59 - 2 - 3 - 4) - (38 - 2 - 2 - 4) - (92 - 1 - 8 - 8 - 6 - 11) - (6) = 358

Twelve percent of the 110 students will ride the shuttle when the shuttle reaches Point C (the trips that are within the one-fourth of a mile walking distance are deducted). Of this number, 12% will ride the shuttle, or 358 x 12% = 43 people; 43 + 14 = 57 riders.

The previous calculation shows that the shuttle should have room for at least 57 people, as 57 people will be in the shuttle at that point.

Summary

This research report analysis shows the flow of trips inside the campus and the trips from the outside of the campus to the inside of the campus. The trips within the one-fourth of a mile walking distance have not been considered because of the rule of thumb that people would walk one-fourth of a mile. From the modal split, we have 12% of the people riding the shuttle and people coming from the parking lot are already on the shuttle. With this consideration, we reach the conclusion that, at maximum point, the shuttle bus has to have room for 60 people. Figure 9 shows the direction of the shuttle around the UCF campus.

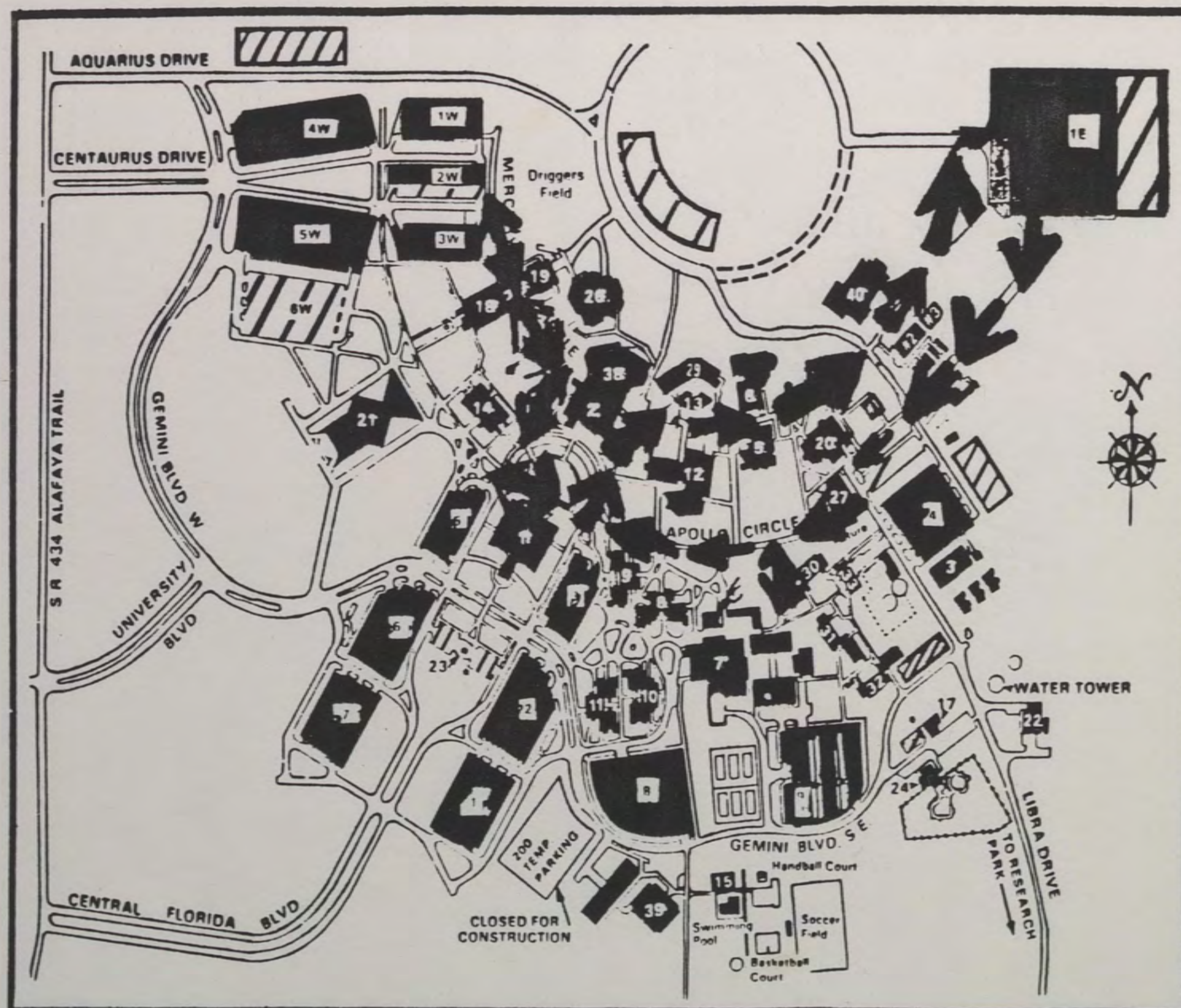


Figure 9. Shuttle Directions Around the UCF Campus (University of Central Florida 1984).

CHAPTER IV

RECOMMENDED SHUTTLE BUS FOR UCF

Westinghouse Electric Corporation, C-10

Several different types of shuttles have been considered. The first type is from Westinghouse Electric Corporation, the C-10. The C-10 is a light-weight vehicle system designed for bi-directional operation at speeds of up to 15 miles per hour. They can carry 14 passengers (6 seated and 8 standing) in each car. These cars are operated as trains with a minimum length of 3 cars (see the attached photograph in Figure 9). The interior of the C-10 vehicle is designed to accommodate passengers in comfort, thereby making the use of the system a pleasant experience. The vehicles have large windows for a panoramic view of the surroundings, are air-conditioned and use automatic doors for quick, easy loading and unloading. The vehicle's floor height is designed to match the height of station platforms for smooth access to boarding passengers.

The guideway serves several purposes in addition to vehicle support. Tractive efforts are accomplished by rubber drive tires, and steering is done with rubber guide tires which follow the lateral contour of the guideway. Power and control signal rails for the C-10 system are installed on the guideway and act to provide electrical power and to control information to the moving vehicle.

The following system configuration was assumed:

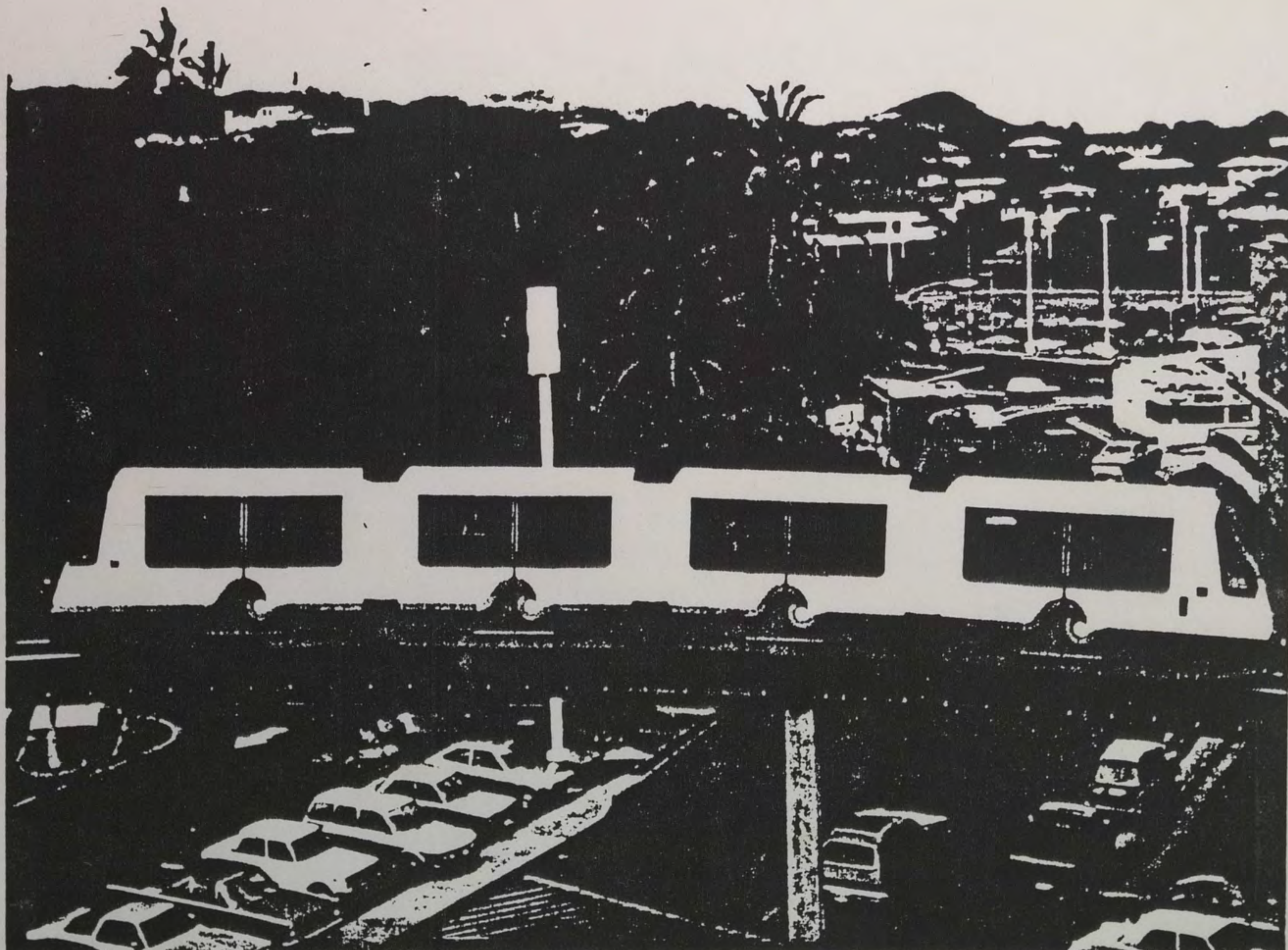


Figure 10. C-10 Shuttle by Westinghouse Electric Corporation.

1. 2500 feet of straight, level, elevated dual-lane guideway
2. two stations, one at each end of the guideway route
3. two three-car trains, one on each of the two lanes
4. system control to provide synchronized automatic shuttle operation

A system of this type would have the following operational characteristics:

1. trip time from station to station: 2 minutes
2. station dwell time: 30 minutes
3. system capacity: over 800 passengers/hour/direction

A very preliminary budgetary estimate for a system of this type would range from approximately $5.5 million to $6.0 million (Westinghouse Electric Corporation 1985). This would include vehicles, guideway, piers, automatic train control, installation and start-up costs.

Unimobile Unitram

The Unimobile Unitram, made by the Universal Mobility, Inc., is a custom-designed activity-centered people mover. It is engineered to meet specific capacity, speed, terrain and theme requirements. The bodies from floor to roof and the comfortably contoured seats are ruggedly constructed of heavy-duty reinforced fiberglass with stainless steel trim and supports. The heart of the system is the heavy-duty Dodge chassis and drive. The Unitram, with its clean line design and gel coat impregnated colors, can operate with up to four vehicles per train and blends beautifully into its operating environment. Figures 10 through 12 show various illustrations of the Unitram.

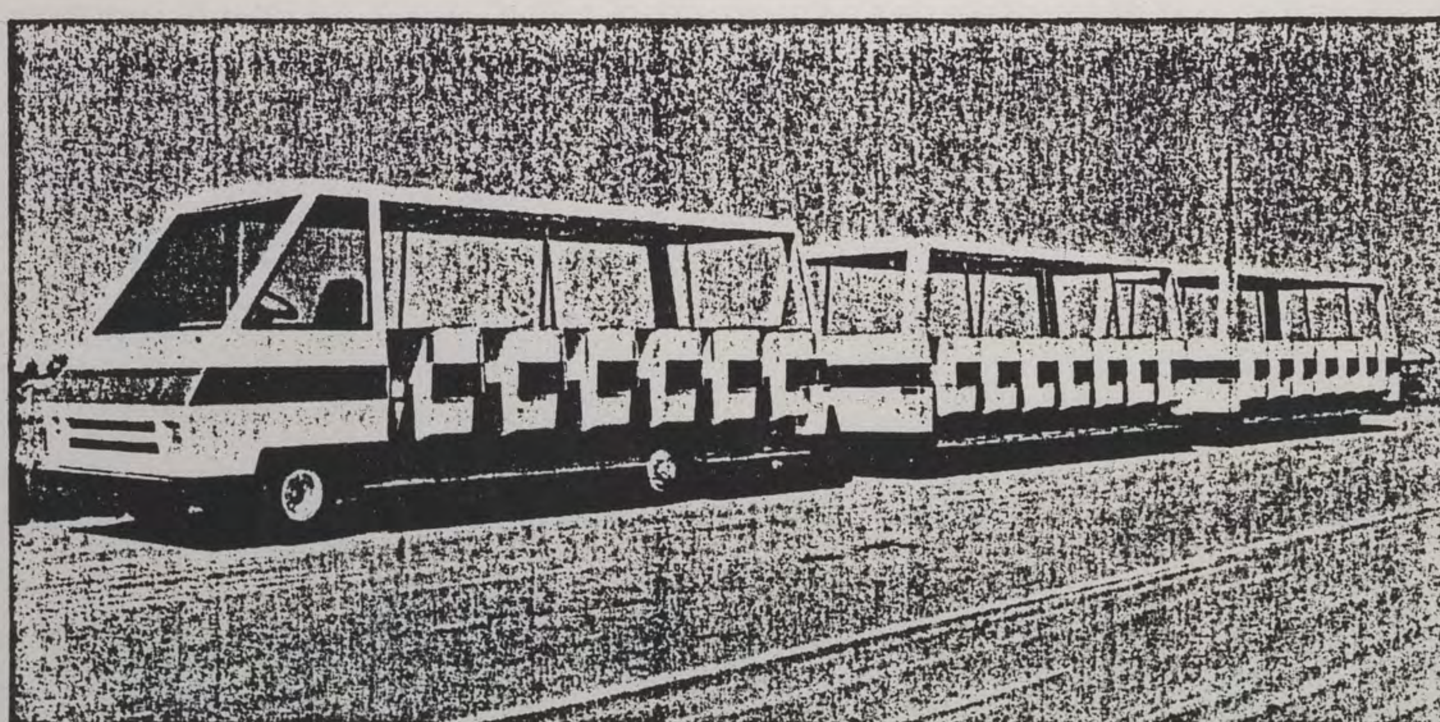


Figure 11. The Unitram by Universal Mobility, Inc.

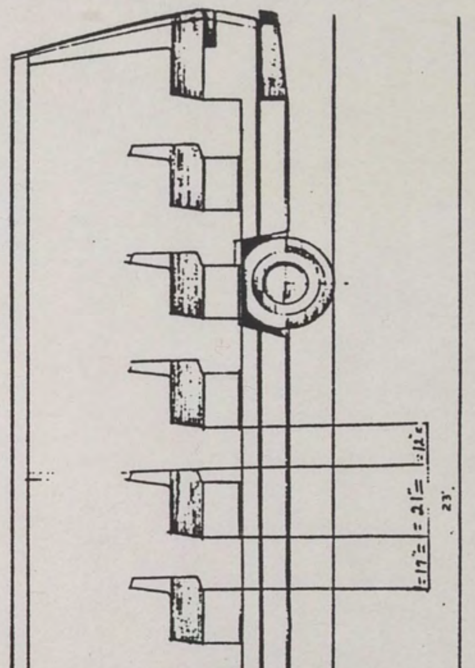


Figure 12. Unitram Dimensional Data.

Figure 13. Close-up of Unitram Shuttle System.

Unitram Specifications

Power Unit:

Capacity:	30 adults or 36 children
Overall Dimensions:	8'6" high, 7'11" wide, 23' long
Gross Weight: (loaded)	12,000 pounds
Seating:	6 contour benches
Wheel Base:	153 inches
Tires:	Michelin high pressure industrial
Brakes:	Power, hydraulic boost
Chassis:	Heavy-duty Dodge motor home
Steering:	Power steering
Lights:	Drive, tail, dome, directional
Sound:	2 channel amp and 2 speakers
Hitch:	Steel rod-end type pivot
Turning Radius:	28 feet to outside corner
Engine:	440 cu. in. - 260 HP (maximum)
Grades:	15% - continuous operation
Transmission:	Chrysler load flite heavy-duty 3-speed automatic transmission with auxillary transmission and oil cooler
Rear End:	13,000 lb. capacity heavy-duty rear axle

Trailer Unit:

Capacity:	35 adults or 42 children
Overall Dimensions:	8'6" high, 7'11" wide, 21' long
Gross Weight: (loaded)	10,000 pounds
Seating:	7 contour benches
Wheel Base:	165 inches
Tires:	Michelin high pressure industrial
Brakes:	Hydraulic disc on each wheel
Chassis:	Heavy-duty welded construction
Steering:	Four-wheel articulation
Lights:	Continuous dome, tail, directional
Sound:	3 speakers and emergency switch
Hitch:	Steel rod-end type pivot
Turning Radius:	25 feet to outside wheel

Unitram Applications

1. Entertainment centers
2. Air transport centers
3. Community centers
4. Educational centers
5. Sports arena centers
6. Zoological centers
7. Commercial centers
8. Industrial centers
9. Recreational centers

10. Shopping centers
11. Civic area centers
12. Cultural centers

Information Needed to Price Unitram

1. Application and use
2. Operating surfaces
3. Capacity per hour
4. Speeds: normal and maximum
5. Snow and ice operations
6. Weather protecting curtains
7. Heating and air-conditioning
8. Delivery date
9. Communications: automatic tapes or manual
10. Type of fuel: gas, diesel or propane
11. Round trip route length
12. Number of stops along route
13. Tour guide requirements
14. Grades and lengths of grades
15. Minimum turning radii
16. Loading station length

The cost for the Unitram is $1000/passenger (the purchase price). The minimum capacity of the shuttle is to carry 57 people. Therefore, one power unit and one trailer unit which would carry 65 people should be purchased. The purchase price would be approximately $65,000 to $70,000, which is much less than the C-10 mentioned in the previous section. This price would enable the University to purchase the Unitram.

CHAPTER V

CONCLUSIONS

This report evaluated the probability of a shuttle bus for the University of Central Florida. With the growth that the University is facing, the need for more parking lots is obvious. The distance between buildings and parking lots is getting further apart. One of the choices to aid the parking problem is to build a parking garage which would provide more spaces for the students, faculty and staff. Also, a shuttle service would be useful to supplement transportation around the UCF campus.

With respect to the goal of providing a parking service and aiding the parking system, in general, a campus Disney-type shuttle and peripheral parking system should be successful at the University of Central Florida. The author considered two techniques for this report. One of the techniques was with counting people, conducting a survey and counting cars. The other technique involved calibrating a model. The result of both techniques was the same. The calibrated model can be used for any year that a new shuttle bus system is necessary (in order to get the trip interchanges). However, at the present time, all that is needed are two trains connected to each other. In this way, as the student enrollment increases, more cars could be purchased and added to the tram. As new buildings or parking spaces are built, all that would be needed is a new production and attraction analysis to determine the new size of the shuttle and the area that it would serve.

Since the cost is a major concern for the shuttle bus system, a potential analysis of a system would be to add $50,000 (an approximate estimate) to cover the cost of a driver, mechanic, gas and insurance. This price would be added to the cost of the Unitram shuttle ($70,000) for a total of $120,000. This amount could be provided by the students, staff and faculty.

If 16,000 students pay $7 per year:	16,000 x $7 = $112,000
If 1,600 staff and faculty pay $7 per year:	1,600 x $7 = $ 16,000
	$128,000

In this way, the shuttle system would be paid for in one year. In 1990, the University could have five shuttles, each one traveling a different route, thereby serving all major locations, including the Research Park and ball games.

APPENDIX

SURVEY

1. What time is your first class?

2. What building is your first class in?

3. If a shuttle bus goes on campus, would you use it to ride to your first class?

4. What building is your second class in?

5. What time is your second class?

6. Would you ride the shuttle to go to your second class?

TABLE 7

FRICTION FACTORS BY TRIP PURPOSE

TRAVEL TIME (MINUTES)	FRICTION FACTORS BY TRIP PURPOSE		
	HBW	HBNW	NHB
1	18	--	70
2	11	100	50
3	8.4	60	28
4	6.6	32	18
5	5.1	14	14
6	4.1	8.0	9.0
7	3.3	5.1	6.0
8	2.7	3.6	4.8
9	2.2	2.6	3.0
10	1.9	2.0	2.4
11	1.7	1.7	1.9
12	1.5	1.4	1.5
13	1.3	1.0	1.0
14	1.1	0.72	0.80
15	0.98	0.57	0.70
16	0.86	0.48	0.56
17	0.78	0.39	0.46
18	0.68	0.30	0.37
19	0.61	0.25	0.31
20	0.55	0.21	0.27
21	0.50	0.18	0.23
22	0.45	0.16	0.19
23	0.40	0.13	0.17
24	0.36	0.11	0.15
25	0.33	0.09	0.13
26	0.30	0.08	0.11
27	0.28	0.07	0.09
28	0.25	0.06	0.08
29	0.23	0.05	0.07
30	0.20	0.05	0.06
31	0.18	0.04	0.06
32	0.17	0.04	0.05
33	0.16	0.03	0.05
34	0.15	0.03	0.04
35	0.14	0.03	0.04

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