PARKING

FOR INSTITUTIONS AND SPECIAL EVENTS

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THE ENO FOUNDATION FOR TRANSPORTATION, INC.
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About the Author

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Prior to joining Wilbur Smith and Associates in 1960, Mr. Whitlock headed the design division of the Virginia Steel Company after serving with the U.S. Army Corps of Engineers in Washington, D.C. He received a B.S. degree in civil engineering from Virginia Military Institute in 1955 and is a Registered Professional Engineer in 17 states, Canada and Australia. Mr. Whitlock is a member of a variety of professional organizations including the National Parking Association's Parking Consultants Council and the Institutional and Municipal Parking Congress. Mr. Whitlock is a member of the Board of Consultants of the Eno Foundation for Transportation.

FOREWORD

A majority of hospitals, medical centers, universities, and similar institutions in urban areas are faced with the problem of providing adequate, controlled parking. Hard pressed to meet skyrocketing costs for essential services and expansion, such institutions are seeking efficient, cost-effective ways of providing parking and traffic facilities. And, just as public demand for new and additional services has influenced institutions to expand, so has public demand for social-recreational-sports activities caused a proliferation of new and expanded facilities to host special events, attracting large assemblages of people and their motor vehicles.

The general trend of change and expansion for institutions and special event facilities has caused their range of operational and parking space needs to change and fluctuate widely, even between similar institutions and activities. This monograph reflects an analysis of current traffic generation and parking characteristic data for institutional-type and special event facilities. It provides current parking ratios and demonstrates why the range of parking ratios now vary more widely than in the past. Emphasis is placed on evaluating parking needs on a site-specific basis in relation to parking characteristics and other variables, using more definitive methods than rule-of-thumb parking ratios to calculate space needs. The author also discusses criteria and guidelines that are useful to those who plan and manage institutional or special event parking systems.

The scope of this monograph has been purposely limited, as its use is meant to supplement and complement information published by the Eno Foundation and others in the field of vehicular parking. The Foundation and author express their appreciation to Frank LaMagna and F. Gregory Lucado, Jr. who assisted in compiling the data comparisons used in this book, and to Robert A. Weant who reviewed and edited the final manuscript.

ROBERT S. HOLMES
President
Eno Foundation for Transportation, Inc.

Metric Conversion Table

Meters	= feet × 0.305
Kilometers	= Miles × 1.609
Square Meters	= square feet × 0.093
Square Kilometers	= square miles × 2.590
Cubic Meters	= cubic feet × 0.028
Cubic Meters	= cubic yards × 0.765
Hectares	= acres × 0.405

(a hectare is 10,000 square meters)

CHAPTER I
INTRODUCTION

Institutions are organizations providing services of a cultural, professional, educational, health, or recreational nature. They range in size from small specialty museums to major facilities, such as medical centers, universities, and sports stadiums. Institutions can have relatively large staffs and attract many people. All institutions are traffic generators that must accommodate the needs of those who use automobiles to visit them. Hospitals, medical centers, colleges, universities, sports stadiums, and other institutional-type and special event traffic generators must provide parking facilities that not only serve the parker's needs, but also serve the institution's needs by providing the necessary parking capacity in the most efficient, cost-effective way possible.

Many institutions have occupied their original locations for years. As a consequence, many are now situated within heavily-developed urban areas, surrounded by a very limited amount of available land on which to expand and store visiting vehicles. Thus it is necessary to fully understand institutional parking characteristics and needs so that available land may be used efficiently.

Recent Trends

As institutions grow in proportion to their service populations, they also must change with prevailing trends in the types of services provided. These changes affect parking space needs and parking facility operations.

Hospitals and Medical Centers

Hospital activity occurring between 1965 and 1979 (summarized in Figure 1) indicates a trend toward more clinical services such as ambulatory care centers and day nursery services administered to outpatients. Outpatients are persons who do not require hospital admission and overnight stays. In addition, physicians are advocating ambulating patients sooner after inpatient surgical procedures than ever before. These trends have resulted in a 23 percent decrease in average length of hospital stay during the 10-year period ending in 1979. During this same period, outpatient visits per 1,000 patient population increased 48 percent.

Outpatient visits increased at an average annual rate of 5.5 percent between 1969 and 1979, while hospital admissions increased at an average annual rate of 2 percent during the same period. When compared to increases in service area population, outpatient services escalated over three times as fast as hospital admissions.

The growth in outpatient services, coupled with the increasing number of support personnel necessary to provide and administer these services, has

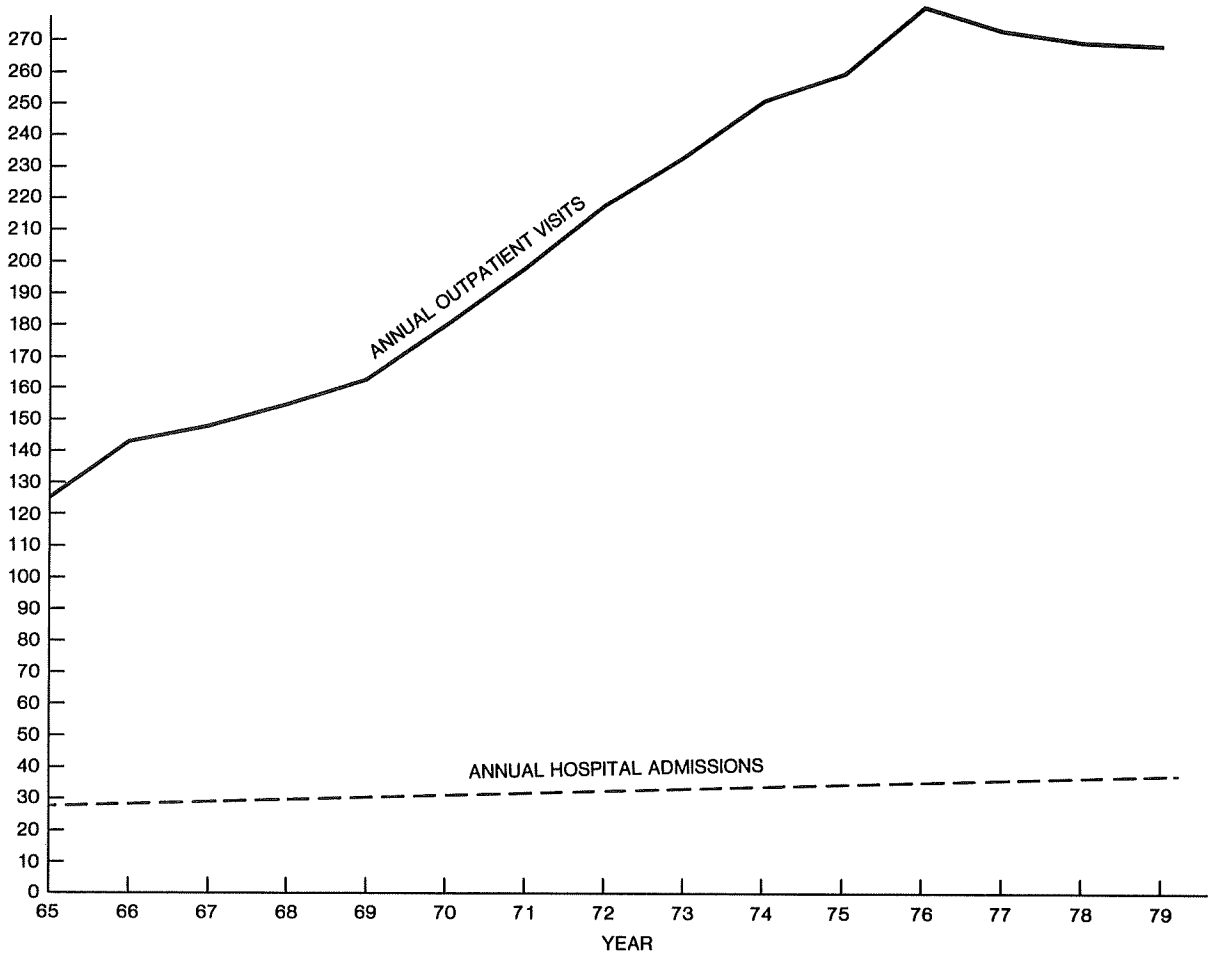


Figure 1. Activity trends of annual hospital admissions and outpatient visits (1965-1979)
Source: American Hospital Association.

resulted in a rise in employment at hospitals. Between 1969 and 1979, the average number of full-time equivalent employees increased 68 percent (from 1.47 to 2.47 persons per hospital bed).

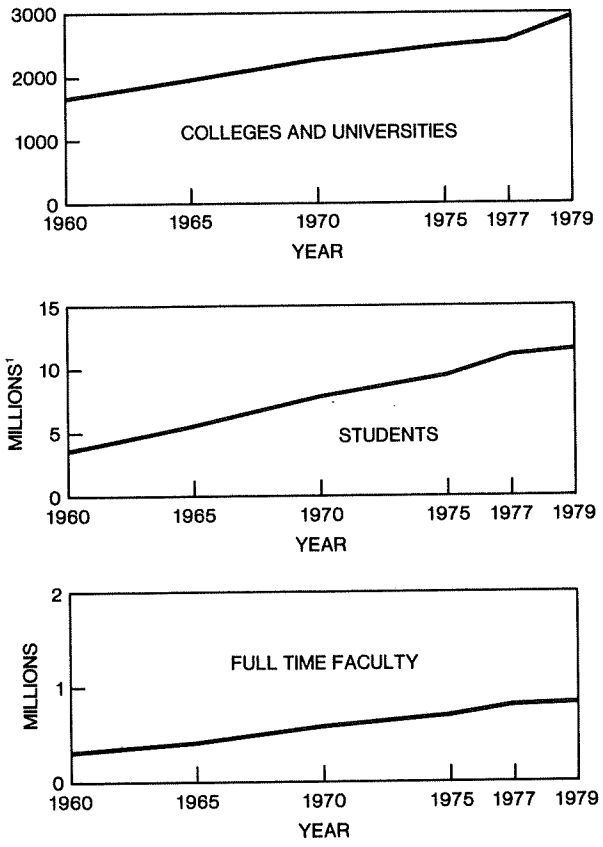
This growth and change in hospital and medical center activity has generally been accompanied by increased vehicular traffic and parking demands. Today, medical facilities compete with each other—more so than ever before. Hospital administrators are vitally interested in the marketability of their institution. Availability of convenient parking and accessibility are essential aspects of the hospital's ability to successfully compete in the market place.

Colleges and Universities

The increasing number of colleges and universities, and the corresponding increases in students and faculty between 1960 and 1979 are shown in Figure 2. The number of colleges and universities in the United States increased 43 percent during the 19-year period. Student enrollment, as well as the number of faculty, more than tripled in the same period.

Average daily campus population also increased dramatically. Between 1960 and 1979, the average daily population of colleges and universities (total enrollment, faculty, and staff) typically doubled.

Because most colleges and universities are major traffice generators, they have tremendous impact on the traffic of their surroundings. This is particularly true for parking considerations. When a parker is unable to find parking on campus, space outside the campus is usurped. This practice can cause strained relations between the institution and the surrounding neighbors. Providing adequate parking is also important to the campus administration, since convenient parking can act as an induce-



[1] Total student enrollment

Figure 2. Growth trends of college and university populations.
Source: Statistical Abstract of the United States 1979 Edition. Selected values from Table No. 263. 1960-1977 U.S. National Center for Education, 1979 volumes.

ment to attract and/or keep faculty and staff members, as well as students.

Special Event Parking

Providing parking for special assemblages such as sporting events, conventions, or exhibitions held at special-purpose facilities, can cover a wide variety of situations. In some instances the range of special parking needs can defy the most flexible system. Special events also occur where permanent specialized facilities for the occasion do not exist, yet provision for vehicular parking remains a necessity.

Changing characteristics of special event parking and the high costs of providing parking, have placed greater emphasis on remote parking with shuttle bus operations; and siting new facilities that are to host special events where they can take advantage of already existing parking, not having concurrent parking demands. The wider range of vehicle sizes and types (motor homes and charter buses, for example) frequenting certain types of special events, makes it necessary to consider segregation of these vehicles in appropriately designed parking layouts.

Purpose and Scope

The purpose of this monograph is to analyze current data pertaining to parking systems of hospitals, medical centers, university and college campuses, and special event generators. Current practice in the design of parking facilities is based on a critical time period of one hour. Each element of a parking facility is dimensioned to properly serve the demand within this critical hour. The design-hour volume represents the maximum number of vehicles arriving or departing a facility within the hour (or a selected period within the design hour) on a typical day. It is especially dependent on the characteristic arrival and departure patterns, as well as other characteristics of the different categories of parkers attracted to the activity generator.

A comparative analysis of traffic generation and parking characteristics for institutional-type and special event facilities is presented. These characteristics are related to typical ranges of parking operation and space needs. In addition, planning criteria and other items of consideration are presented as general guidelines for those who plan and manage institutional and special event parking systems.

This text supplements other parking publications focusing on institutional parking. It has been developed as an addendum of information and update to previous Eno Foundation publications on parking, specifically: *Access and Parking for Institutions,* 1960, and *Parking and Access at General Hospitals,* 1973.*

*Wilbur S. Smith, *Access and Parking for Institutions,* 1960 (out of print) and George E. Kanaan, *Parking and Access at General Hospitals,* 1973 were both published by the Eno Foundation, Westport, Connecticut.

CHAPTER II
HOSPITALS AND MEDICAL CENTERS

In 1979, 7,000 hospitals were operating in the United States, employing over 33 million persons. It is estimated these hospitals attract about 7.5 million persons daily, an average of 5.5 persons per bed.

Most hospitals are confronted with a parking problem. Problems range from the high costs of parking space development to a lack of space in convenient locations. These problems are frequently accompanied by a divergence of opinion as to daily administrative and operational needs of parking facilities.

The culmination of characteristically different parkers into a single parking system is another cause of the parking problem confronting hospital administrators. Employees, physicians, patient-visitors, outpatients, volunteers, clergy and students comprise the base hospital population daily. Each of these groups has individual travel characteristics and parking needs that should be recognized and provided for in a convenient and economically prudent fashion. Solutions to the parking problems must consider the short- and long-run needs of the institution.

Table I presents a summary of activity trends at hospitals and medical centers, reflecting a 48 percent growth in outpatient activity and a 42 percent increase in full-time employees per hospital over the 10-year period ending in 1979. Average daily inpatient census, adjusted for population growth, declined 37 percent during the same period.

Hospital Types

Hospitals function as one of two basic types for purposes of evaluating their parking characteristics. These are general hospitals and medical centers. General hospitals provide acute care inpatient clinical and surgical services, as well as outpatient services. Medical centers generally provide those services, including a full range of outpatient services, while accommodating teaching and research activities. Medical centers also contain medical office buildings, affording office space for the practicing physicians. Medical centers are often the focal point of university medical schools and research programs.

The principal operational difference between medical centers and general hospitals as related to parking is the ratio of daily employees and visitors to beds. Typically, a center has a greater population per bed in contrast to the general hospital. General hospitals typically provide fewer than 400 beds on the basis of a national average.

In addition to medical institutions categorized as general hospitals and medical centers, there are other facilities serving particular needs such as children's hospitals, psychiatric, and rehabilitation

TABLE I – RECENT ACTIVITY TRENDS: HOSPITALS AND MEDICAL CENTERS IN THE UNITED STATES 1969-1979

Activity Indicator	1969	1979	Percent Change
Total Hospitals and Medical Centers	7,144	6,988	– 2
Total Beds	1,650,000	1,372,000	
(Per 1,000 Population)	8.1	6.2	–23
Average Daily Patient Census	1,346,000	1,043,000	
(Per 1,000 Population)	6.6	4.8	–37
Admissions	30,729,000	37,802,000	
(Per 1,000 Population)	151.6	172.2	+14
Average Length of Stay – Days Short-Term Care Facility	8.3	7.6	– 8
Outpatient Visits	163,248,000	262,009,000	
(Per 1,000 Population)	805	1,194	+48
Full Time Employees Per Hospital	340	484	+42
Full Time Employees Per Bed	1.47	2.47	+68

Source: American Hospital Association, *1980 Hospital Guide.*

hospitals, free-standing dialysis centers, and extended care facilities. These specialty hospitals provide specific levels and types of outpatient and inpatient services. The size and staff composition of these types of facilities are also specialized.

Specialized medical facilities can exhibit travel and parking characteristics that differ from those typical of hospitals and medical centers. Characteristics of parking and travel generation at general hospitals may apply to some specialized medical facilities; however, the individual nature of any specialized facility should be studied and planned on a site-specific basis.

Medical centers on university campuses are influenced by many of the same factors as university parking systems. Proximity of student and faculty housing and the proportion of students commuting to the medical center are key factors.

Travel and Parking Characteristics

Characteristics of sampled hospitals and medical centers are presented in Appendix Tables A-I and A-II. References to specific medical facilities use the alphabetical designations assigned in the appendix tabulations.

Hospital and Medical Center Population

The daily population of hospitals and medical centers is categorized as staff and visitors, based on the average duration and frequency of their visit. Staff members, with the exception of attending physicians, volunteers and clergy, remain all day while working at the facility. Physicians have special parking requirements dictated by their need for mobility and their daily schedules. Visitors generally have short-term stays, less than 3 hours.

As shown in Table II, staff and visitors are divided into various categories, representative of the individual parking demand segments of hospital and medical center populations. Typically, the staff consists of employees, interns/residents, attending physicians, students, volunteers, and clergy. Visitors include visitors of patients, business visitors, emergency room visitors, persons arriving for outpatient care, and private physician visits.

Staff members typically comprise less than half of the total daily population. Medical center staff comprise a greater percentage of total daily population than that of general hospitals. This is largely due to the portion of a medical center's staff necessary to support teaching and research activities, as well as the level of student population.

Visitors comprise about 63 percent of a typical general hospital's daily population compared with 59 percent at medical centers. This reflects a higher proportion of inpatient visitors at general hospitals, as well as the greater proportion of staff in a typical medical center's daily population.

Data presented in Table II are generally representative of the population distribution within general hospitals and medical centers. A concentration or lack of certain activities, such as educational programs in a university hospital-medical center, will cause significant variations in these values.

Staff Population. A typical 350-bed general hospital with an average outpatient activity level will likely have between 800 and 1,100 staff members arriving daily. A moderately-sized medical center with 750 beds will perhaps have a much higher daily population of staff, ranging from 2,000

TABLE II – DAILY POPULATION DISTRIBUTION: GENERAL HOSPITALS AND MEDICAL CENTERS

Population Segment	Distribution of Persons			
	General Hospitals		Medical Centers	
	Percent	Percent of Total	Percent	Percent of Total
Staff				
Employees	83	31	87	36
Interns/Residents	1	1	4	1
Attending Physicians	8	2	2	1
Students	3	1	6	2
Volunteers/Clergy	5	2	1	1
Total/Subtotal	100	37	100	41
Visitors				
Inpatient Visitors	78	49	71	40
Business Visitors	3	1	4	3
Emergency Room Visitors	9	5	9	5
Outpatient/Private Physician Visits	10	8	16	11
Total/Subtotal	100	63	100	59

Source: Compiled from data of selected hospitals and medical centers listed in Appendix Tables A-I and A-II.

to 3,500 persons. The wide range of staff complement at medical centers can be attributed to the diversity and type of research and teaching programs sponsored by the given institution.

Visitor Population. Daily visitor and outpatient populations of hospitals and medical centers vary greatly between facilities of similar size, location, and inpatient bed capacity. Studies reveal daily visitor and outpatient arrivals ranging from 0.4 persons per bed to over 16 persons per bed. This range can normally be attribued to the volume of clinical outpatient services rendered by specific units. Activity centers, such as walk-in clinics, concentrated pediatric services, or on-campus medical office buildings typically generate high visitation levels that tend to increase the ratio of visitors to beds. Because of widely varying generation factors, it is unwise to plan parking facilities at medical institutions solely on a "per bed ratio" as in years past.

Daily Population Acitivity. Table III presents a summary of daily population activity at medical facilities on the basis of patient bed capacity. Daily population activity is lowest at extended-care facilities having an average of 2.8 staff members per bed and 2.4 visitors per bed. Specialty hospitals have the highest average daily activity rates with an average of 4.5 staff members per bed and 6.0 visitors per bed.

A comparison of medical centers with general hospitals indicates significantly more staff and visitors per bed at medical centers. This is largely because of increased outpatient business, and the broader spectrum of services typically provided at medical centers.

Seasonal Activity Peaks. An important consideration in assessing parking needs at medical institutions is the activity level of the institution. Occupancy rate, average length of stay, and admissions are the prime indicators (indexes) of hospital activity.

Figure 3 presents national averages for monthly

TABLE III – SUMMARY OF DAILY POPULATION ACTIVITY AT MEDICAL FACILITIES

Type of Facility	Number of Study Centers	Number of Daily Persons per Bed	
		Staff	Visitors
Medical Centers	15		
Average		4.5	5.0
Range		2.2–16.0	2.7–8.5
General Hospitals	15		
Average		3.4	4.1
Range		2.0–6.5	1.4–9.5
Extended Care Facilities (Long-Term)	3		
Average		2.8	2.4
Range		1.4–3.6	0.4–4.2
Specialty Hospitals	3		
Average		4.5	6.0
Range		3.0–6.0	1.7–16.0

Source: Based on analysis of data for selected study hospitals, and medical centers listed in Appendix Tables A-I and A-II.

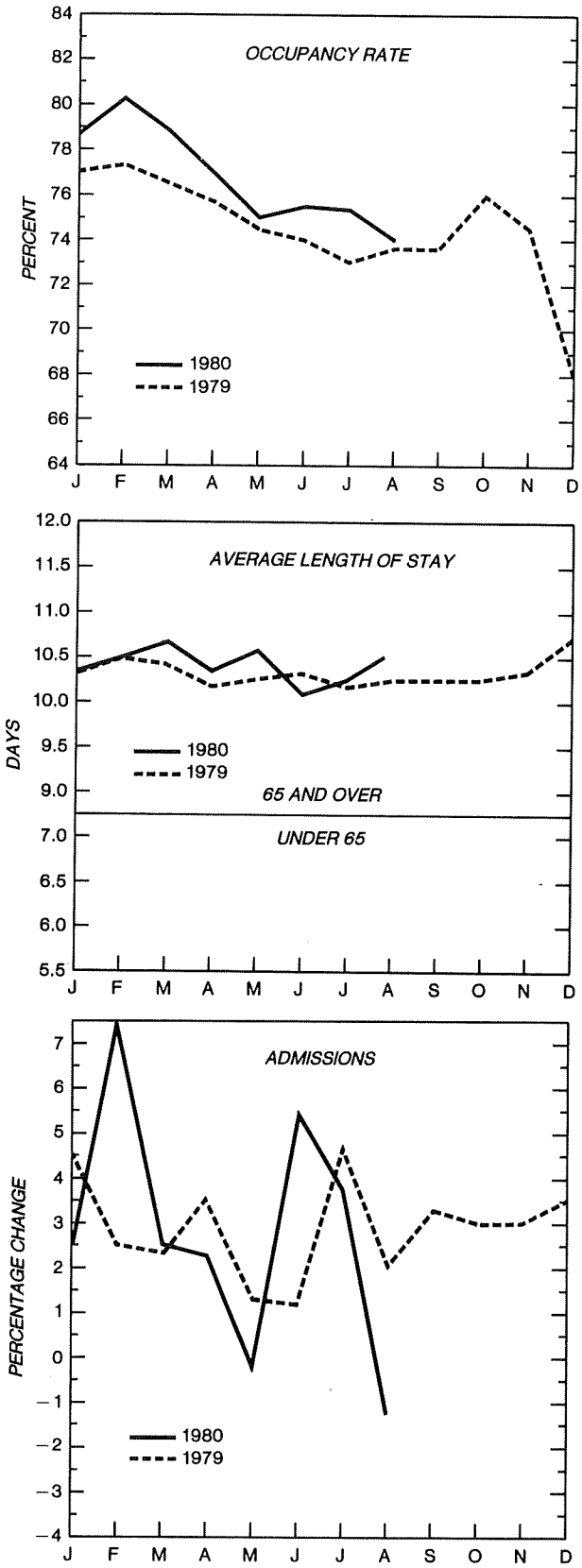


Figure 3. Hospital activity indexes.
Source: Hospital Data Center, National Hospital Panel Survey.

hospital activity. Bed occupancy, average length of stay, and admissions in fall and winter months (with the exception of December) are normally above average. Thus, in planning medical institution parking, consideration should be given to the peak period of admissions occurring during the fall and winter months.

Mode of Travel

Important in determining the demand for parking at a hospital is the arrival mode of staff and visitors. The private automobile is the predominant travel mode across the nation. During 1975, 84.7 percent of all person trips to work in the United States were by private automobile. This characteristic reflects the public's desire to have the convenience, comfort, security, and reliability of the private automobile. Hospital employees, visitors, and outpatients also prefer the private automobile travel mode.

Travel Mode and Hospital Location. Characteristics of individual hospitals provide a good indication of the population portion that can be expected to arrive by automobile. General hospitals in affluent suburban locations can be expected to have a high percentage of private automobile arrivals. Studies of four selected general hospitals in affluent suburbs found the automobile used by nearly 94 percent of everyone arriving on a typical weekday.

In contrast, visitors to the "neighborhood hospital," which serves a small densely-populated urban area, have a lower incidence of automobile usage. Two such hospitals within a major eastern city have an automobile usage of just over 50 percent. Employees and staff made up the majority of these motorists, with most outpatients and visitors electing to walk the short distance to their neighborhood hospitals. Transit usage accounted for 10 to 15 percent of visitor and outpatient trips.

Another characteristic affecting mode of arrival is public transit accessibility. If an efficient, reliable transit system exists, employees working at a medical institution can be expected to rely on private automobiles to a lesser degree. Research of medical facilities accessible by efficient public transit, found the average automobile usage to be 63 percent of person trips contrasted with the average of 79 percent for selected medical facilities listed in Appendix Tables A-I and A-II.

University hospitals and medical centers have relatively low automobile usage. The typically close proximity of these facilities to a central business district and large numbers of students accounts for an average 67 percent automobile usage, as determined in studies of five university hospitals and medical centers. Another contributing factor to the lowered use of private automobiles is the practice of medical centers providing shuttle bus service from housing areas to the medical facilities for staff, visitors, and outpatients of the academic community.

Travel Mode and Trip Purpose. Not every individual visiting a hospital or medical center becomes a parker. The purpose of an individual's visit is an excellent statistical indication of modal choice.

A study of data on four general hospitals with average overall automobile arrival characteristics was conducted to determine automobile usage characteristics by trip purpose, as shown in Table IV.

Each of the sampled hospitals, although exhibiting slight variances, portrays the general characteristics reflected in the average. Physicians rely on the automobile due to their daily routine and need for travel time and destination flexibility. Most physicians see patients and perform medical procedures at several locations daily. Because of demands on their time and the intensity of daily schedules, the personal automobile is their first mode of choice. This reliance on the private vehicle is further intensified by the fact these physicians travel alone and, therefore, can each be expected to require ready access to an available parking space at their destinations.

In comparison to physicians, visitors, hospital employees, and outpatients reveal less reliance on the private automobile with automobile usage averaging 93, 88, and 83 percent, respectively. These statistics can be considered typical of hospitals not served by an active transit system, nor located in a university environment.

TABLE V – PERCENT OF PEOPLE ARRIVING AT GENERAL HOSPITALS BY AUTOMOBILE

Person Category	Auto Drivers	Auto Passengers	Percent of Total Person Arrivals
Employees/Staff	78	10	88
Outpatients	57	26	83
Visitors	61	32	93
AVERAGE	65	23	88

Source: Based on comparative analysis of data for four general hospitals listed in Appendix Table A-I.

Employees, visitors, and outpatients arriving by automobile are not all drivers. Analysis of data from four general hospitals studied provides a generalized idea of the percentage of people arriving by automobile as shown in Table V. An average of 65 percent of those arriving at hospitals (excluding physicians) are auto drivers. The 10 percent of employees and staff arriving as auto passengers indicates a slight, yet significant proportion of ride-sharing among this group. This trend will more than likely increase in popularity as fuel costs and other personal auto expenses escalate.

Outpatients often are dependent on others for access to hospitals for treatment. Other hospital visitors generally arrive in groups with family or friends to visit hospitalized patients. This tendency is reflected in Table V with 32 percent of visitors arriving as automobile passengers rather than drivers.

Parking Accumulation and Duration Patterns

Hospital parking systems must accommodate needs of a variety of parker types. Each parker type has their individual perceived needs – needs related to such characteristics as arrival time, dura-

TABLE IV – AUTOMOBILE USAGE BY TRIP PURPOSE AT SELECTED GENERAL HOSPITALS

	Percent of Person Trips at Four Selected Hospitals														
	Hospital L			Hospital H			Hospital I			Hospital F			Average		
Person Category	Auto Drivers	Auto Passengers	Total Auto Use	Auto Drivers	Auto Passengers	Total Auto Use	Auto Drivers	Auto Passengers	Total Auto Use	Auto Drivers	Auto Passengers	Total Auto Use	Auto Drivers	Auto Passengers	Total Auto Use
Physicians	96	1	97	100	–	100	97	–	97	98	–	98	98	–	98
Employees/Staff	70	19	89	78	7	85	87	9	96	77	5	82	78	10	88
Outpatients	69	22	91	47	48	95	69	28	97	44	7	51	57	26	83
Visitors	73	19	92	47	48	95	68	31	99	55	31	86	61	32	93

Source: Based on comparative analysis of data of selected study general hospitals listed in Appendix Table A-I.

TABLE VI – TYPICAL DAILY ACTIVITIES: HOSPITALS AND MEDICAL CENTERS

Daily Activity	Time of Day
Nursing Service Shift Change	7:00 A.M.
Business Offices Open	9:00 A.M.
Clinics Open	9.00 A.M.
Afternoon Visiting Hours Begin	1:00 P.M.
Nursing Service Shift Change	3:00 P.M.
Afternoon Visiting Hours End	4:00 P.M.
Business Offices and Clinics Close	5:00 P.M.
Evening Visiting Hours Begin	6:00 P.M.
Evening Visiting Hours End	8:00 P.M.

tion of visit, mode of travel, and amount the parker is prepared to pay for parking. The combined influence of these characteristics results in a particular pattern for the accumulation of parked vehicles.

Daily hospital events attracting parkers, and the time of day they occur, cause complex patterns of parking accumulation. Daily activities occurring at a typical hospital are shown in Table VI. Events listed are those that influence trip making by employees, staff, physicians, visitors, and outpatients.

Hourly Accumulation Patterns. A graphic portrayal of the hourly accumulation patterns of parkers is shown in Figure 4. Prior to 9:00 AM, the majority of parkers constitute staff. During the peak period of parking (2:00 to 3:30 PM), 60 percent of all parkers are staff, 15 percent are patient visitors, and 5 percent are outpatients. The remaining 20 percent comprise attending physicians (1 percent), students (3 percent), volunteers (2 percent), and all others (14 percent).

Peak hour of parking usually occurs between 2:00 and 3:30 PM, during the second shift change. At this time, second shift personnel arrive at the hospital prior to the majority of the first shift departures. Figure 5 illustrates the parking accumu-

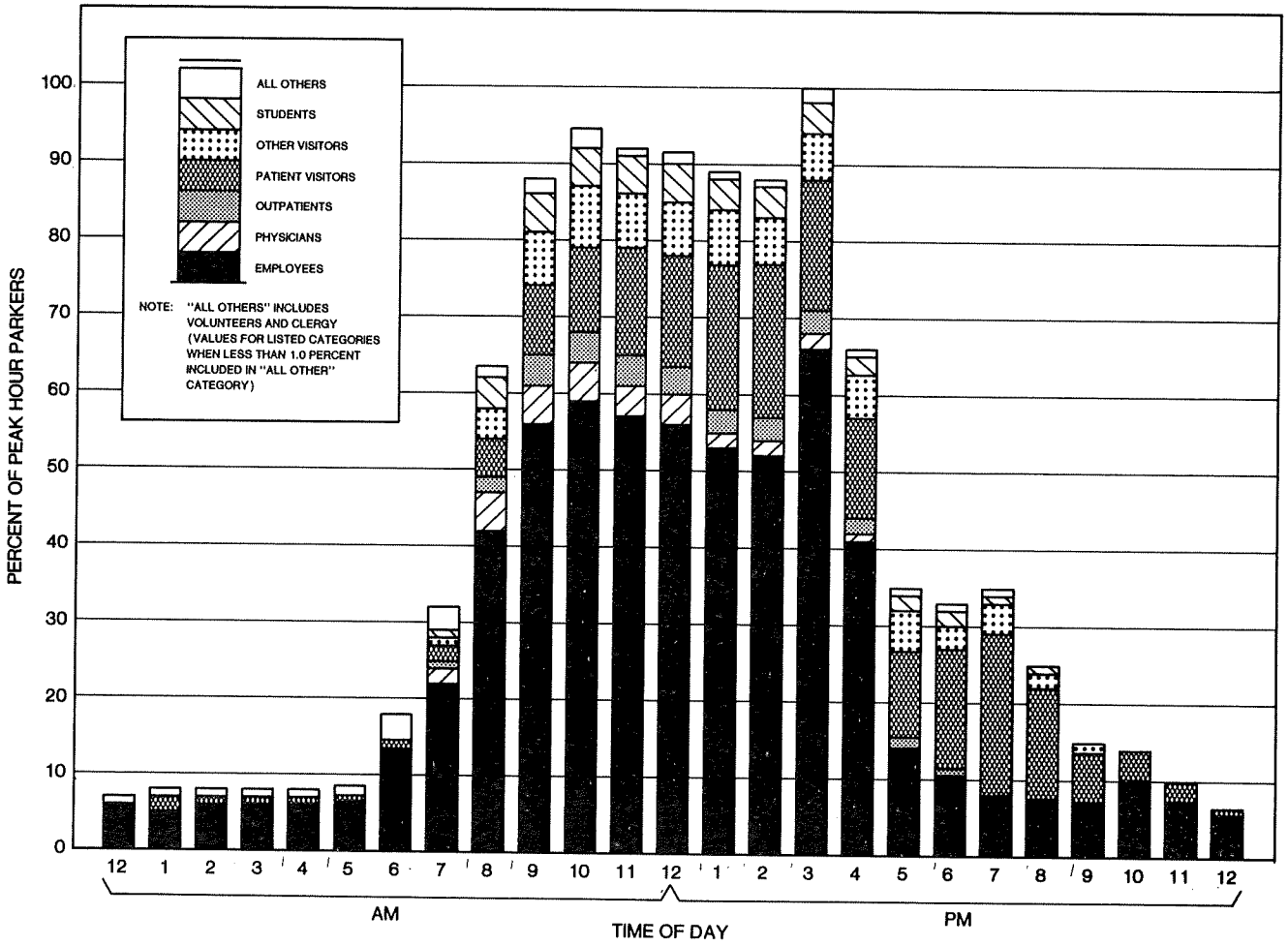


Figure 4. Hourly accumulation of parkers by type.
Source: *Wilbur Smith and Associates.*

lation curves for employees, students, attending physicians, and volunteers.

Typically, the peak period for physician parking is during the morning hours between 7:00 and 9:00 AM. Employee parking on the other hand, is relatively constant between 9:00 AM and 3:00 PM; a significant drop in employee parking occurs between 4:00 and 5:00 PM.

Student parking peaks in the late morning hours between 10:00 AM and 12:00 Noon, declining in the afternoon. Similar to students, volunteers are more prevalent in the morning hours and leave gradually during remaining times of the day and evening.

Figure 6 illustrates the hourly accumulation patterns of hospital visitors and patients. Outpatient parkers peak at 10:00 AM. Visitors of patients essentially have two peak times daily—2:00 and 7:00 PM. These peak periods are directly related to visiting hours established by hospital/medical center policies. Approximately 50 percent of the peak hour parking space requirement will be occupied at 10:00 AM, and up to 100 percent at 2:00 PM.

Total parking accumulation is a derivative of the individual accumulation patterns of the institution's population. Peak-hour parking is largely dependent on the attraction of hospital activities associated with each population group described in the accumulation patterns presented in Figures 5 and 6.

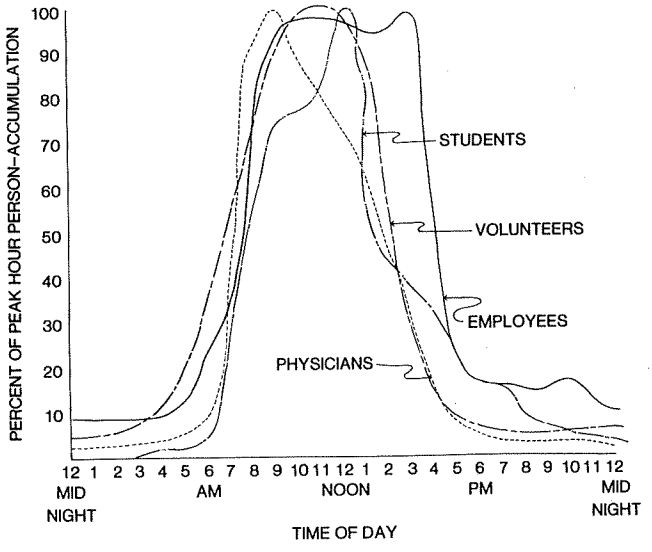


Figure 5. Accumulation patterns of hospital staff.
Source: Derived from analysis of data of 14 general hospitals listed in Appendix Table A-1.

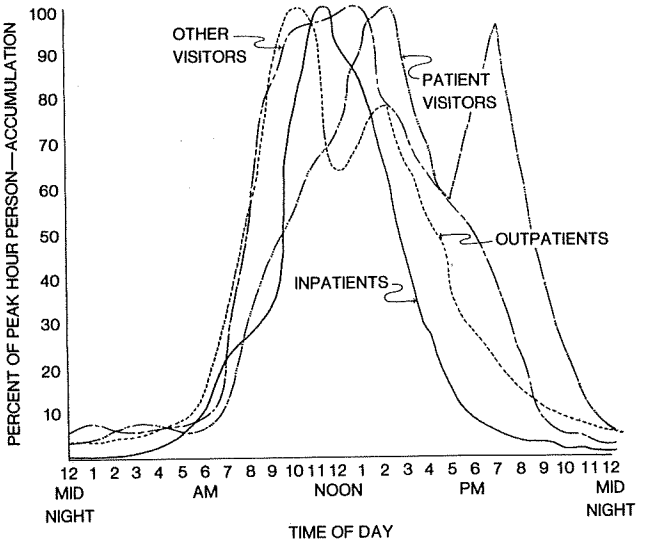


Figure 6. Accumulation patterns of hospital visitors and patients.
Source: Derived from analysis of data of 14 general hospital, listed in Appendix Table A-1.

The accumulation of visitor and outpatient parkers at hospitals and medical centers varies among facilities. These parkers are attracted to the hospital based on scheduling of outpatient services, physicians' office hours, and hospital-imposed restrictions on patient visiting hours. These times are different among hospitals because of individual operating characteristics, policies, and local customs.

Some hospitals have rather constant visitor and outpatient activity levels throughout the day while others have morning or afternoon peaks. The greatest influencing factors on parker accumulation are the customary office hours of physicians and hospital visiting hours.

Parking Duration Patterns. One element affecting the amount of parking space required at a hospital or medical center is the duration patterns of parkers. Table VII presents a breakdown of typical parking durations by type of parker. Of the staff parkers, 71 percent of all employees have durations over 8 hours. Parking durations of attending physicians vary, with 50 percent having durations less than 4 hours. The overall average for all staff parkers indicates that 5 percent have durations of 4 hours or less.

Visitor parking durations are much shorter, with about 86 percent of all patient visitors parking for less than 3 hours. The average duration of staff

TABLE VII – FREQUENCY DISTRIBUTION OF PARKING DURATIONS: HOSPITALS AND MEDICAL CENTERS

Duration of Parking	Type of Parker (Percent)						
	Staff			Visitors			
	Employees	Attending Physicians	All[a]	Patient Visitors	Other Visitors	Outpatients	All
0-1 Hour	Neg.	10	Neg.	34	30	25	31
1-2 Hours	Neg.	14	1	38	44	33	41
2-3 Hours	1	9	2	14	15	22	17
3-4 Hours	2	17	2	4	2	12	3
4-8 Hours	26	48	29	7	5	8	5
Over 8 Hours	71	2	66	3	4	Neg.	3
Total	100	100	100	100	100	100	100
Average Duration	7.8 Hrs.	4.5 Hrs.	7.5 Hrs.	2.2 Hrs.	1.9 Hrs.	2.2 Hrs.	1.9 Hrs.

[a] Total staff includes employees, attending physicians, students, and volunteers.
Source: Based on analysis of data of selected hospitals and medical centers listed in Appendix Tables A-1 and A-2.

parkers is 7 hours, 35 minutes compared to the 1-hour, 55-minute average parking duration for visitors. Parking duration patterns for outpatients extend from 2 to 6 hours, however, 89 percent stay less than 3 hours.

Planning for Medical Institution Parking

Medical facilities are adding wings for outpatient and other expanded services, decreasing available space for vehicular parking at a time when more parking spaces are needed for additional staff and patients. Parking several blocks from a hospital is not acceptable to most people visiting a medical facility, particularly patients. Patients are more likely to request care at hospitals with convenient parking, both for them and their visitors. Convenient and adequate parking is a fringe benefit that also helps attract the best caliber of doctors and employees.

Some medical facilities may have sufficient land for adequate uncontrolled surface parking and they may be philosophically committed to the concept of "free" parking. Nevertheless, medical facilities should have an evaluation of the capital value of their parking areas to determine the annual operating and maintenance costs, as well as the capital costs involved, when new construction is contemplated. This information provides the basis for considering the potential financial productivity and the recapturing of costs.

Among the host of planning criteria, the following are especially stressed for medical facility parking.

1. Based on a comprehensive assessment of space demand, availability, location and priority, there must be a valid determination of the number of spaces required to serve anticipated needs.
2. There should be barrier-free access to the main and emergency entrances and loading areas.
3. Parking areas should be combined, if possible, so that the number of control points is reduced and the most efficient use is made of available space.

Parking Space Needs

The number of spaces needed is the key factor in all other considerations. It must be considered in relation to user characteristics, building layout, and site constraints. Parking demand (needs) at hospitals and medical centers is generally regarded as equivalent to the average peak parking accumulation. Parking demand varies directly with the size of the medical institution's population and its activity, and with the degree of automobile use. Parking facilities should be large enough to accommodate the afternoon shift change, which is the peak time for parking. Shift overlaps and visiting hours contribute to this peak.

Because of the many differing activities taking place in combination at individual hospitals and medical centers, planning ratios of total daily population to such fixed indicators of size as number of beds are unreliable for estimating parking needs. In order to evaluate parking space needs, total daily

population size and composition of medical facilities should be accounted for on a site-specific basis. Statistics are readily available from the hospital administrators relating to these factors, and should be augmented by employee questionnaires and visitor surveys to determine parking demands.

Adjacent and nearby street parking can also be included as part of an existing hospital's parking supply. However, the feasibility of using street spaces to satisfy part of the calculated total parking needs depends on many factors that include: (1) existing and proposed street parking regulations, (2) abutting land uses, (3) street traffic circulation/crossings and proposals (such as conversion to a one-way street system) that might affect circulation, (4) walking distance (preferably not more than 350 feet), and (5) actual as well as perceived pedestrian/parker amenities affecting security, comfort and convenience. Federal regulations can also affect medical facility parking.

The State Department of Health guidelines for short-term (acute area) hospitals require adequate sized *off-street* parking stalls be provided at a minimum ratio of 1.5 spaces for each licensed patient bed to satisfy the minimum needs of patients, employees, staff and visitors. In addition, U.S. Department of Health, Education and Welfare requirements suggest, in the absence of a formal parking study, a ratio of one space per day shift employee and staff member, plus one space per licensed bed. These regulatory requirements are generalized, therefore they can only be used as a guide.

For example, in a 300-bed general hospital (see Appendix hospital "O") located in the northeast, between 454 and 750 parking spaces would be required based on the above HEW requirements. The actual requirement as a result of a parking study is 600 spaces. Similarly, medical center "D" in the Appendix would require between 1,050 and 2,300 parking spaces. A parking study concluded that 1,575 parking spaces were actually needed.

Parking Needs Per Bed. While space-per-bed ratios are not accurate enough to estimate parking needs for today's medical institutions, they can provide preliminary guidance and a basis for comparing site-specific study findings. Prior to the trend of increased outpatient business, the ratio method was sound for planning purposes. Hospitals provided similar basic services and were similarly staffed. This is no longer the case. Outpatient activity continues to increase at all medical facilities across the country as they offer a variety of specialized, more sophisticated outpatient services.

As a result, hospitals should be analyzed separately to ascertain the activity mix influencing parking demand calculations. For this reason, a true assessment of parking space demand can only be developed on a site-specific basis accounting for the individual activity characteristics of the institution. Ingredients used in prior studies may still be valid, but ratios now vary more widely.

Recent data on general hospitals, for instance, reveals the average ratio of peak parker accumulations to hospital beds to be 2.2, with ratios ranging from 1.31 to 3.0 parkers per bed (see Table III). A similar analysis, made in 1973, determined an average ratio to be 1.78 parkers with a range of 0.81 to 2.80 parkers per bed.

These data demonstrate the trend to increasing activity at hospitals resulting in a corresponding increase in parking space demands. They also demonstrate the wide range of space-per-bed ratios that now prevail. It is this wide range that reduces the value of historical ratios for planning indexes.

Figure 7 depicts parking needs as related to numbers of beds. Parking needs range from 1.6 to 2.4 spaces per bed at general hospitals. As illustrated in the figure, a ratio of 1.6 spaces per bed is typical for a general hospital having about 0.5 daily outpatient visits per bed and 50 percent of employees driving autos to work. The value of 2.4 parking spaces per bed represents an outpatient activity level of about 1.0 persons per bed per day, and 75 percent of the staff arriving at the hospital as auto drivers.

A similar analysis was made for medical centers, as shown in Figure 8. Parking space needs generally range from 2.5 to 3.4 spaces per bed. A medical center with minimum outpatient activity (including outpatient to private physicians) and a staff-auto driver affinity of about 50 percent, needs about 2.5 parking spaces per bed. Higher outpatient activity and greater reliance on private vehicle commuting increases this range to 3.4 spaces per bed.

Parking Needs Per Person. A more definitive parking space needs estimation can be derived using four variables:

1. typical daily staff population;
2. typical daily visitor population;

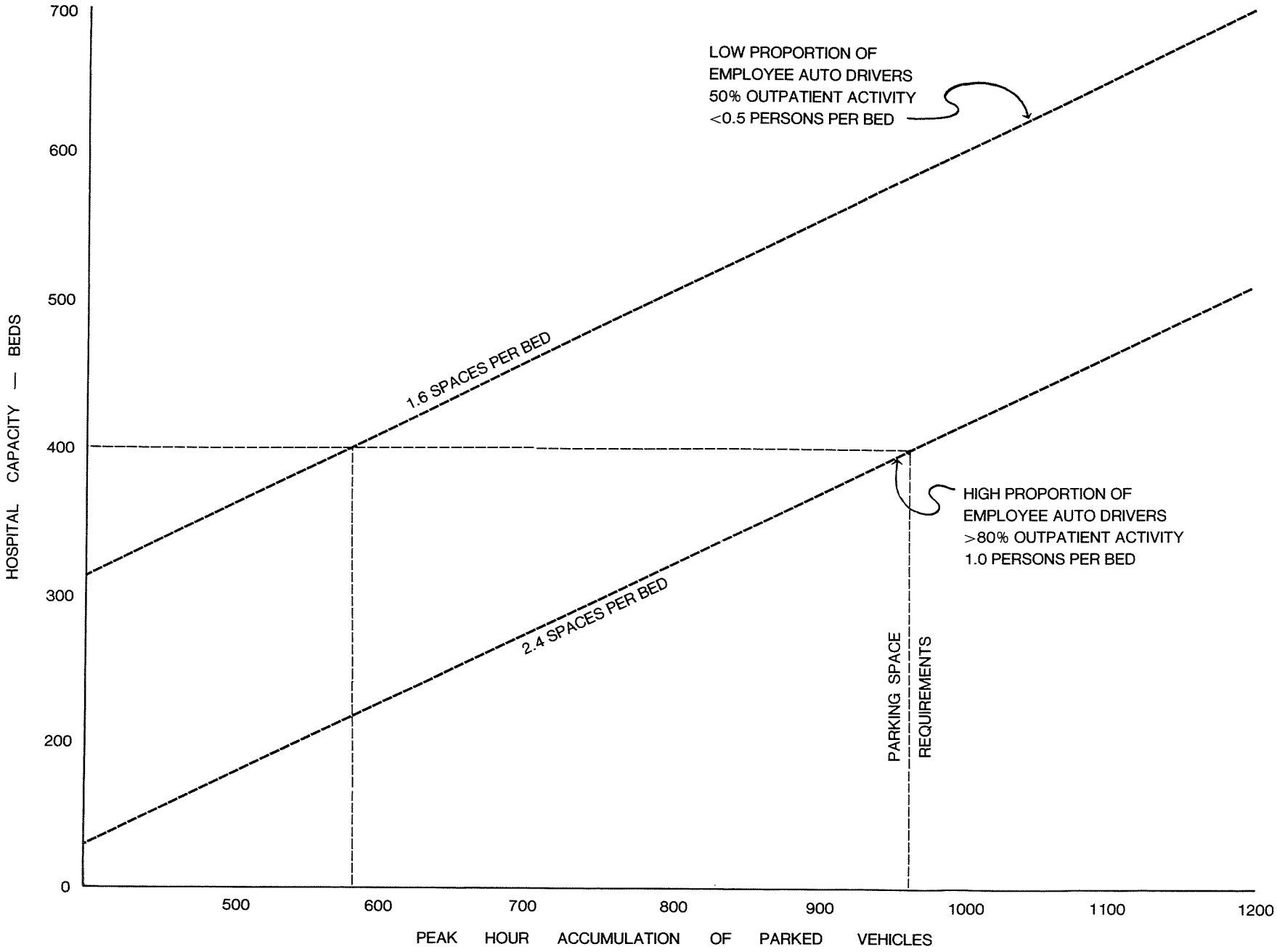


Figure 7. Parking space needs of general hospitals.
Source: Derived from analysis of data of 14 general hospitals listed in Appendix Table A-1.

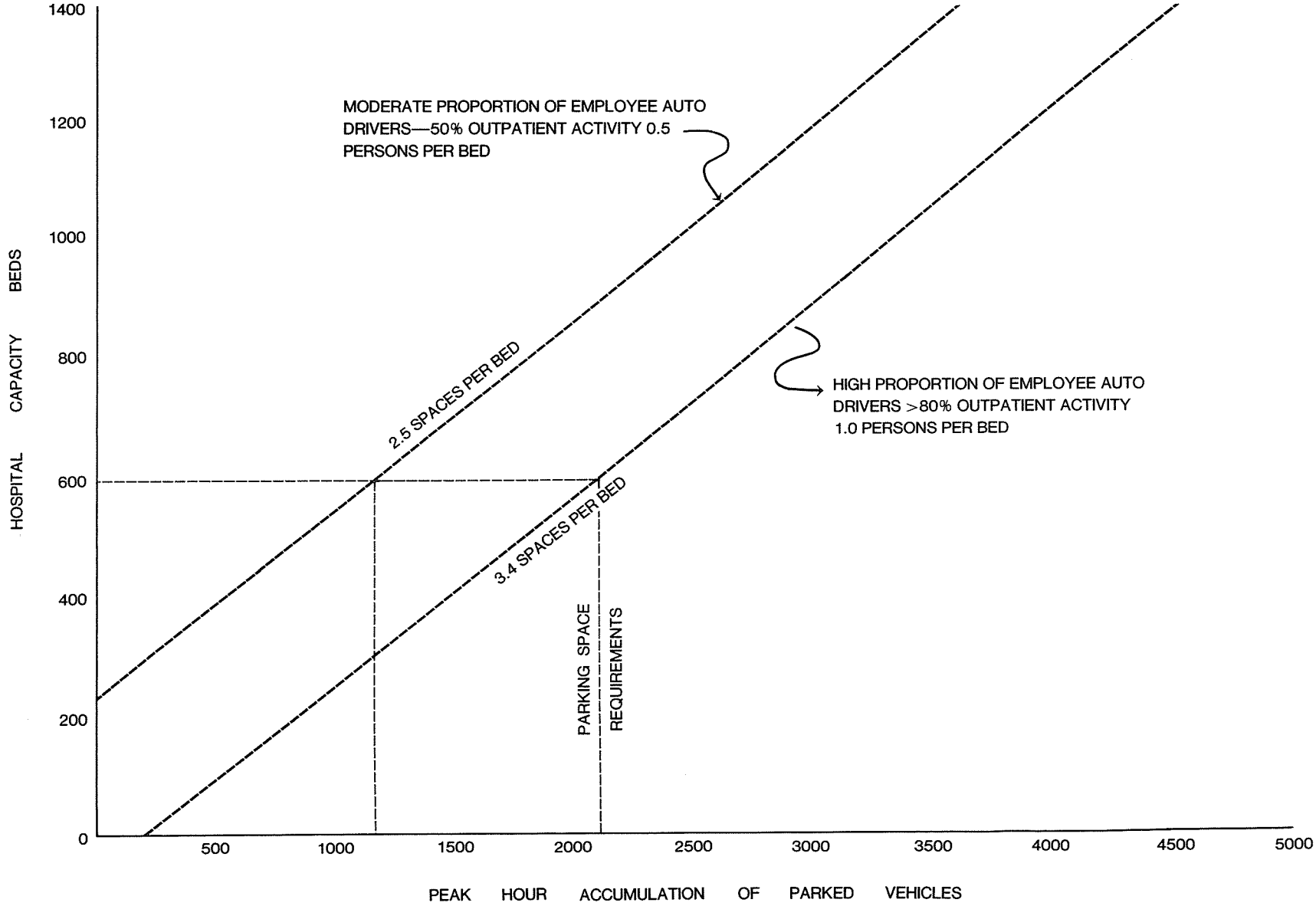


Figure 8. Parking space needs of medical centers.
Source: Derived from analysis of data of 8 medical centers listed in Appendix Table A-2.

3. percent of staff being auto drivers; and
4. percent of visitor being auto drivers.

Slope of the reference lines in Figures 9 and 10 is influenced by peak-hour accumulation and parking duration. Thus, by applying the appropriate factor of auto drivers, the specific parking space requirement can be extrapolated from this family of curves.

Parking Space Allocation. Fluctuations of various demand segments for medical facility parking throughout a typical day is a key consideration. Figure 11 shows parking space usage by category of parker for medical facilities at three points of time during a typical weekday (10:00 AM, 3:00 PM, and 7:00 PM).

At a typical medical facility the daily peak parking space demand usually occurs at 3:00 PM. As shown in Figure 11, 66 percent of the peak hour parking requirements are occupied by employees. Patient visitors account for 17 percent of the peak demand, and the remaining 17 percent of the parking spaces serve other elements of the daily population.

The composition of parking space demand, by category of parker, varies throughout the day. As depicted in Figure 11, at 10:00 AM patient visitors require 11 percent of the daily peak parking space needs. This value nearly doubles in the early evening hours (7:00 PM) with patient visitors needing 20 percent of peak-hour spaces. Variations in employee parking space demand have significant impact on the percentage of total parking spaces in use at various times of the day. At 3:00 PM, the shift change creates the peak demand for employee parking, contributing to that hour's characteristic as the daily peak of parking space demand. Parking space demands of day and evening shifts overlap. Many nursing personnel are required to fill out daily reports at the end of their shifts; as a result overlap often occurs with the second shift arrivals. Figure 12 shows the parker accumulation patterns of each work shift and the cumulative effect on peak-hour accumulation of employee parking. The general distribution of peak demands by time of day is shown in Table VIII. As previously noted, employees peak at 3:00 PM, outpatients peak at 10:00 AM, and visitors peak at 7:00 PM.

If parking spaces were reserved by population category for the entire day to serve the peak period needs of each parking demand segment, the resulting number of required parking spaces would be 10 to 25 percent greater than the actual daily peak-hour demand for spaces. This emphasizes the need for medical facility parking systems to be flexible in operations and location. For example, spaces used by employees and outpatients during the morning and afternoon can serve the peak period patient visitor parkers in the early evening. Similar dual-use operations may combine to provide more efficient use of parking space.

TABLE VIII – HOUR OF PEAK PARKING SPACE DEMAND: HOSPITAL AND MEDICAL CENTER DEMAND SEGMENTS

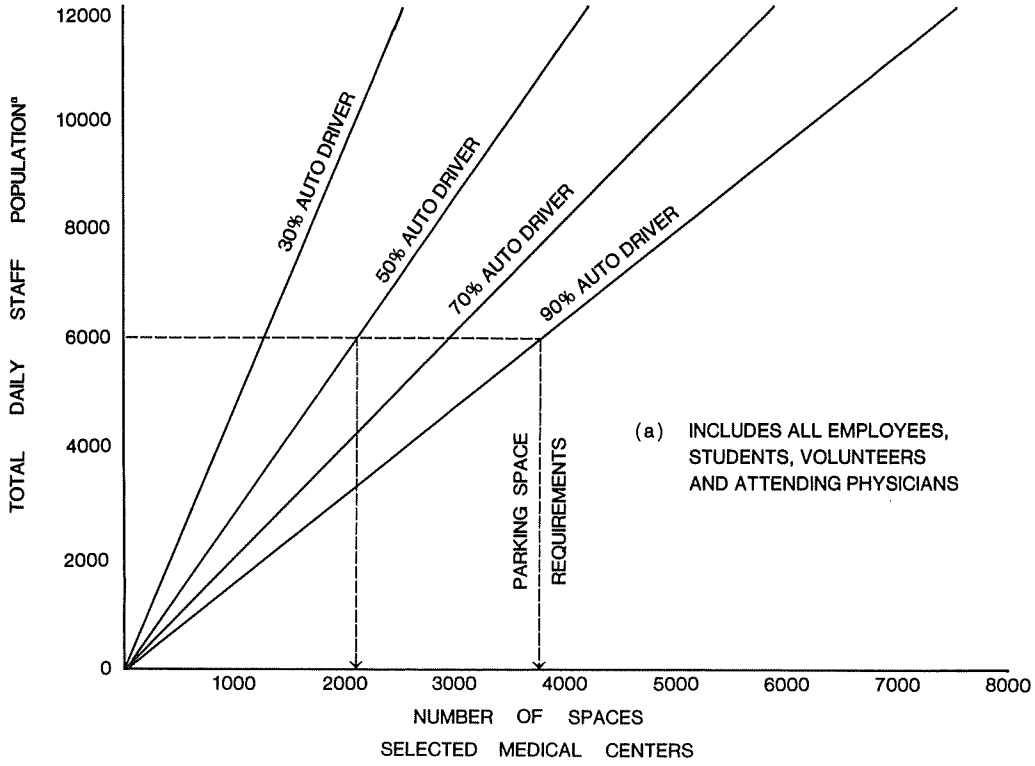
Parking Space Demand Segments	Time of Peak Demand
Attending Physicians	9:00 A.M.
Outpatients	10:00 A.M.
Students	10:00 A.M.
Others	10:00 A.M.
Other Visitors	11:00 A.M.
Patient Visitors	7:00 P.M.
Employees	3:00 P.M.

Source: Based on analysis of accumulation data from 15 hospitals and medical centers.

Financial Considerations

Cost of parking space development, operation, and maintenance, and how those costs will be recaptured, are the basic financial considerations in providing parking space. The available site for parking will help determine whether parking spaces will be surface or in a garage structure, as well as architectual and logistical considerations, all of which will affect costs. Having an idea of what the estimated costs are, opens the way for other considerations such as how the costs can be financed, the annual cost to defray the capital and operating expenses, and the ramifications of user fees for parking.

Development, Operation, and Maintenance Costs. Table IX presents a summary of costs associated with medical facility parking development, operation, and maintenance. Estimated per-space construction costs of $1,200 for surface and $6,000 for above-grade parking structure are given for order-of-magnitude comparison of cost by time of parking. Total development costs are derived based on these construction costs including typical costs of design, legal and financing fees, insurance



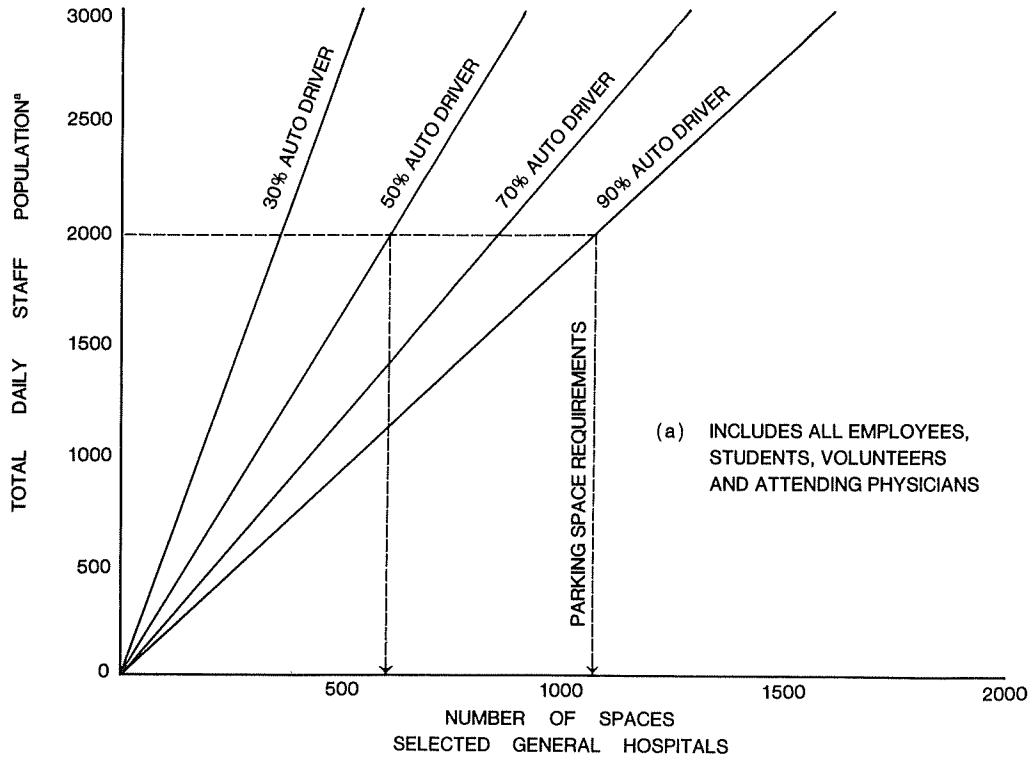
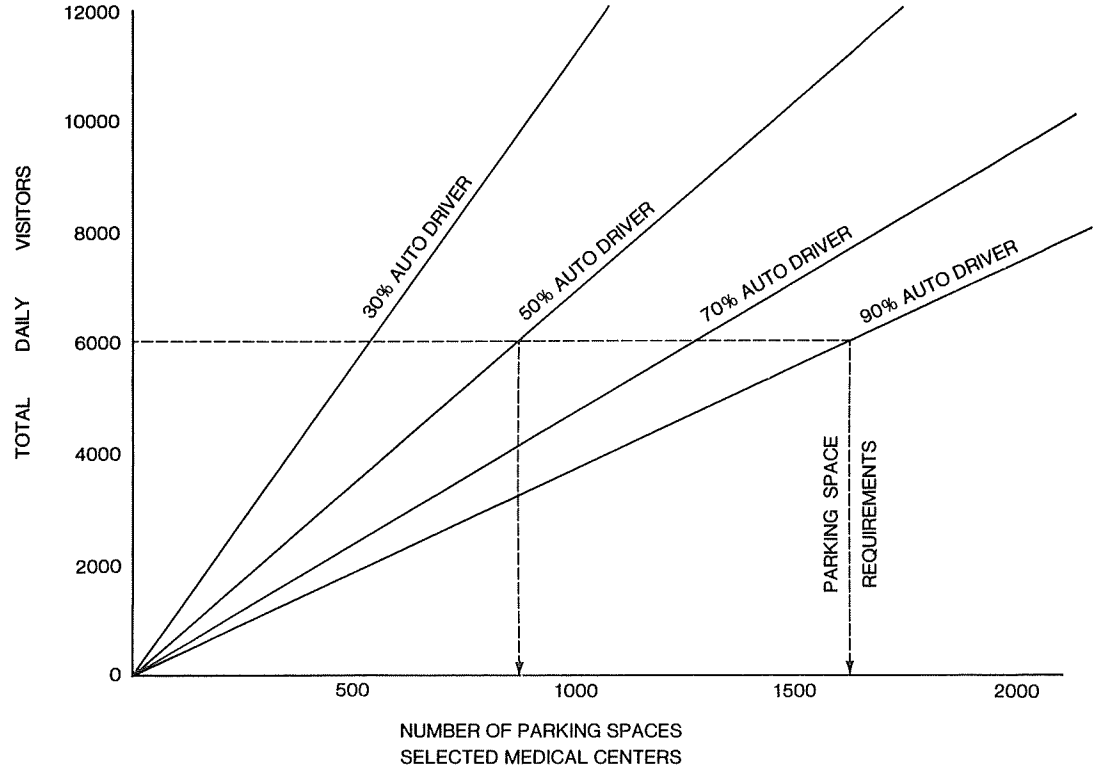


Figure 9. Peak-hour parking space requirements for staff at selected general hospitals and medical centers. Source: Based on comparative analysis of characteristics of 14 general hospitals and 10 medical centers listed in Appendix Table A-1.



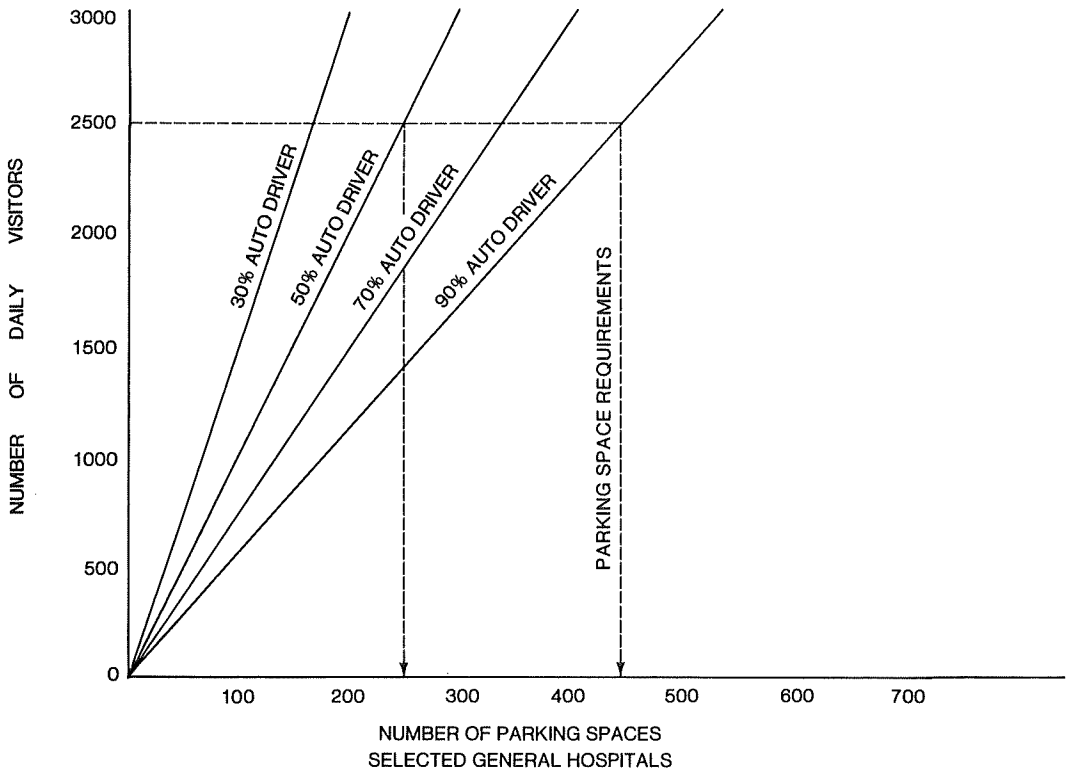


Figure 10. Peak hour parking space requirements for visitors at selected general hospitals and medical centers. Source: Based on comparative analysis of characteristics of 14 general hospitals and 10 medical centers listed in Appendix Table A-1.

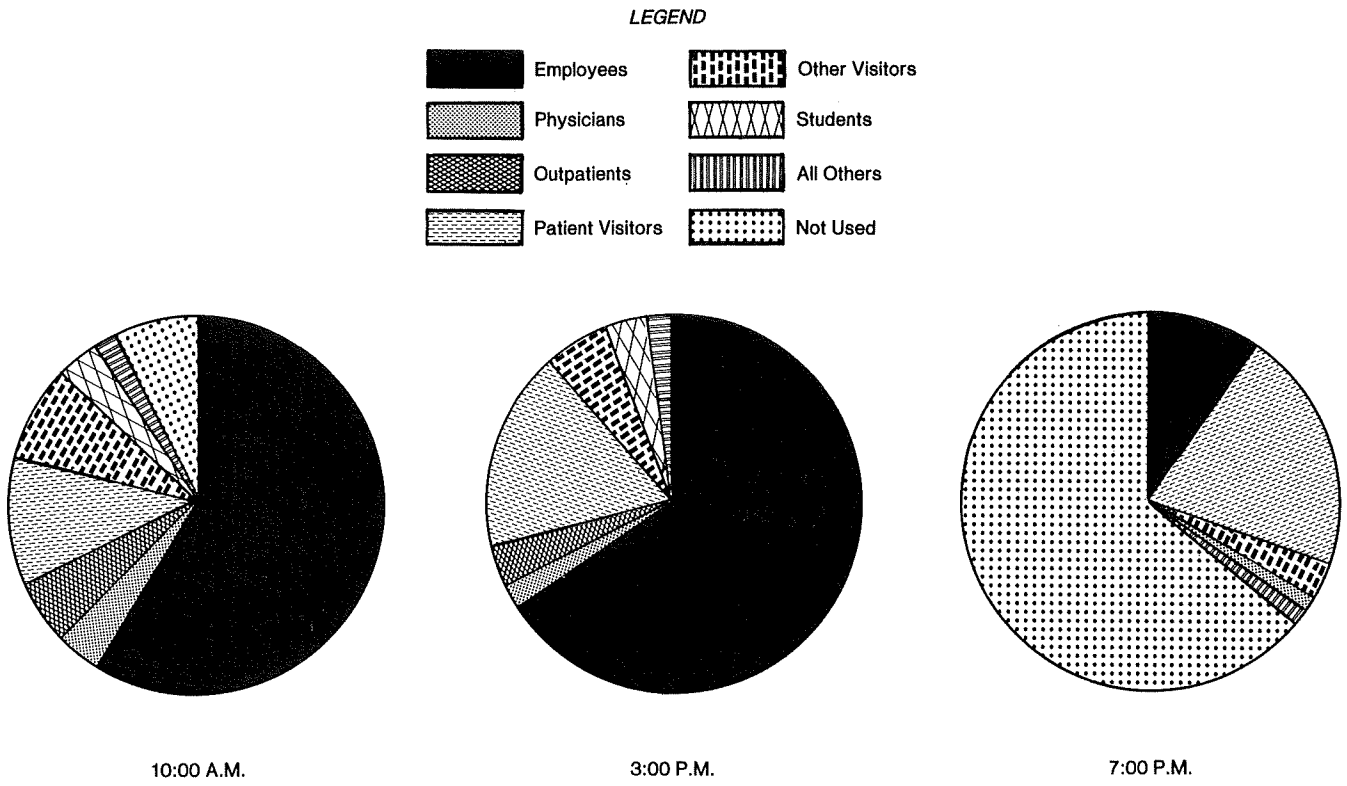


Figure 11. Hospital parking space allocation for typical weekday.
Source: *Wilbur Smith and Associates;* derived from analysis of data from 14 general hospitals.

during construction, and other factors. Land costs are not included.

Annual operating costs are estimated at $100 per space for surface lots, $220 for above-ground structures, and $300 for below-ground parking. These costs include labor, insurance, utilities, maintenance, and other typical operating costs. Administrative and management costs are excluded from these estimates.

Annual debt service costs for each facility shown in Table IX are based on tax revenues for finance with an interest rate of 11 percent and a 29-year amortization period, allowing one year of the 30-year bond period for construction.

Total annual expenses, per space, as shown in Table IX, are the sum of operating and debt service expenses. These estimates are $275 for surface parking, $1,085 for an above-ground garage, and $1,600 for below-ground parking. Based on the hospital parking system operating 365 days per year, these costs result in a daily cost to operate and finance each parking space of $0.75 for surface spaces; $3.00 for structured above-ground spaces; and $4.40 for below-ground spaces.

Recapturing Parking Space Costs. Using an average parking space turnover rate of 2.4 total daily parkers per peak period parking space, the average parking revenue per parker required to offset costs can be estimated. Parkers at surface parking facilities would be required to pay an average $0.30; above-ground garage parkers, $1.25; and below-ground garage parkers, $1.80.

The per parker costs uniformly distributed to employees and visitors would result in a monthly cost to each employee parker of about $7.00 for a surface parking space, $30.00 per month for an above-ground parking garage, or $40.00 for an underground parking space.

Land cost estimates must be added to these figures to ascertain the true per space charge if all costs are to be amortized. As employee parking privileges at many medical facilities are considered an employment benefit, it is difficult to effect these rates to the employees. Health insurance guidelines and regulatory agencies in many areas allow the cost of providing employee parking to be subsidized as an expense of employee benefits. Employee unions have also stipulated, in some

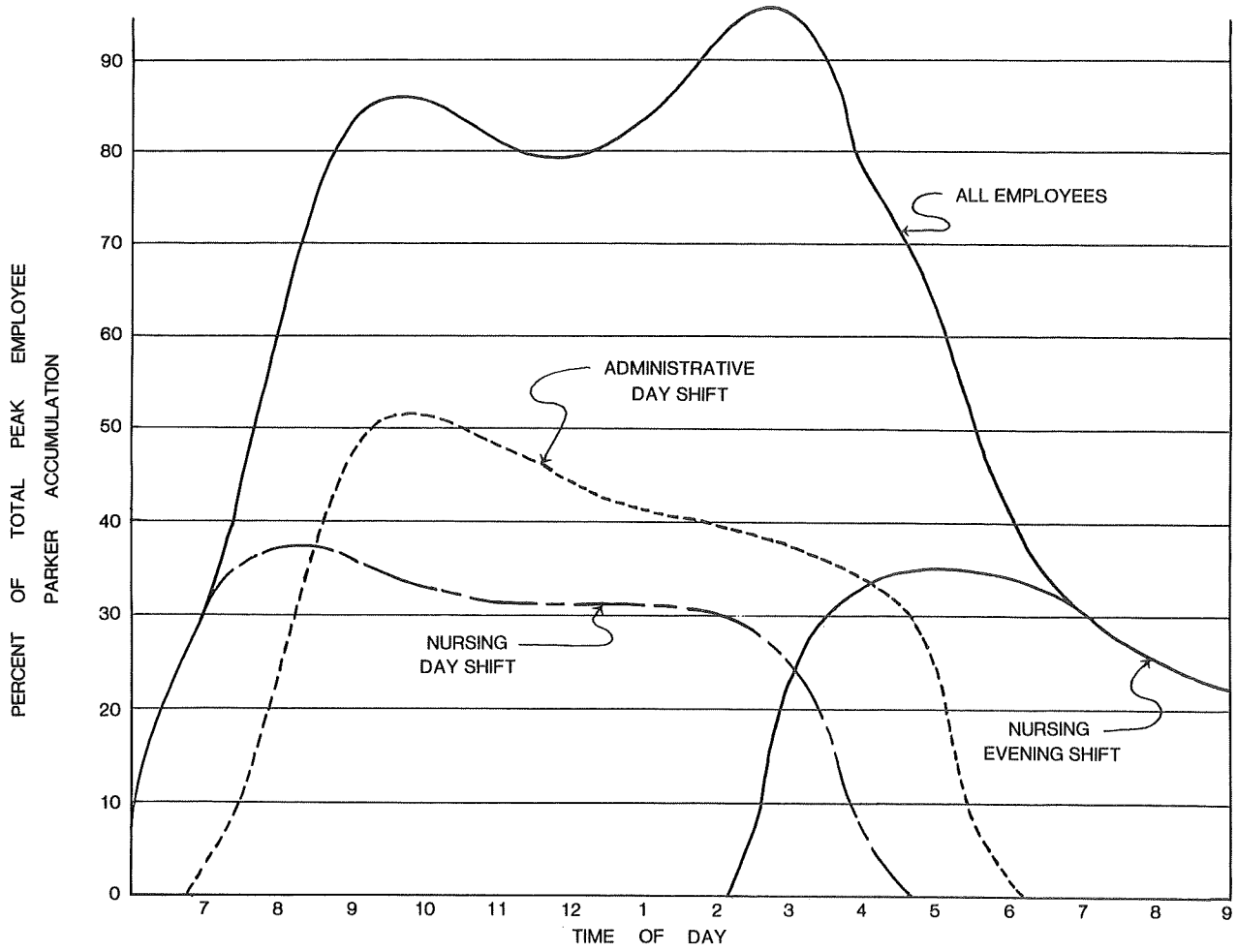


Figure 12. Accumulation of employee parkers at general hospitals and medical centers.

instances, that parking be free of charge to employees.

Many hospitals provide "free" visitor parking, however, there is a trend to charge for visitor parking. Parking revenues not only help to offset development, operation, and maintenance expenses, but also aid in controlling unauthorized use of parking spaces and to establish priorities in the use of parking spaces. There is also an increasing trend for hospitals in metropolitan areas to charge employees and professional staff for hospital parking.

Where employees and staff are not charged for parking, visitors, through a higher disproportionate parking rate can subsidize employee parking. A typical medical facility parking system requires two-thirds of its parking spaces for employees, whereas visitor parking activity results in about two-thirds of the total daily vehicles using medical facility parking spaces.

Parking is never "free." Regardless of whether the medical facility charges the user for parking, the actual costs must be known – especially the costs of lighting, maintenance and cleaning that are often underestimated or ignored initially. Besides rather obvious reasons to have an accurate estimate of parking costs, such knowledge is also necessary to establish to what degree parking is being subsidized, and to provide a reserve or sinking fund for the eventual repair/replacement of facilities.

Functional Design Considerations

Functional design should be considered early in the planning process. For medical facility parking, particular consideration should be given to factors affecting access and the efficient use of space.

Entrances to medical facility parking should be clearly marked. Access for emergency room admissions should be conspicuous and have sufficient

TABLE IX – FINANCIAL CONSIDERATIONS OF MEDICAL FACILITY PARKING SYSTEMS

Item	Estimated per Space Calculations		
		Structured Garage	
	Surface	Above Ground	Below Ground
Estimated Construction Cost[a]	$1,200	$6,000	$ 9,000
Estimated Total Development Costs[b]			
Tax Free Financing @ 11 percent	1,500	7,500	11,200
Estimated Annual Debt Service[c]			
Tax Free Financing @ 11 percent	175	865	1,300
Estimated Annual Operating Costs[d]	100	220	300
Total Annual Expenses	$ 275	$1,085	$ 1,600
Required Per Space Income Per Operating Day[e]	$ 0.75	$ 3.00	$ 4.40

[a] Values reflect comparative cost of the three types of parking assuming compatible amenities. Land costs are excluded from these figures.
[b] Includes design fees, financial-legal fees, insurance during construction, capitalized interest paid during construction at 11.0 percent,and interest on investments received for the construction fund.
[c] Based on a 30-year bond, level debt service payments over a 29-year amortization period.
[d] Based on a conventional operation including cashier labor cost, and all other normal operation expenses such as maintenance costs, utilities, insurance, supplies, and enforcement. Excluded from these costs are administration expenses, and management fees.
[e] Based on 365 days of operation per year.

driveway, building hangover, etc. dimensions to allow passage of oversize vehicles (recreational vehicles, for instance, as well as larger ambulances). Ample parking should be provided as near as possible to the emergency room entrance. Special design arrangements should be made to allow one or more ambulances (depending on anticipated activity) to unload directly to the emergency room entrance, without interfering with other vehicular and pedestrian traffic.

Adequately-sized passenger loading zones should be provided at building entrances. Suitable access and loading areas should also be provided for service vehicles and delivery trucks. If possible, the access and parking requirements for delivery vehicles should be separated from the employee-patient-visitor parking system.

At hospitals where visitor and outpatient parkers are to be served, parking areas should be conveniently located to channelize pedestrians to their proper destination and minimize walking distance. Emphasis must be placed on accommodating the physically incapacitated and handicapped.

While a 90 degree parking/two-way traffic system is more space efficient and economical than angle parking, it should normally only be considered for parking areas designated principally for employee parking. Angle parking allows vehicles to move in and out of parking spaces more easily, and has the inherent safety of one-way traffic movement. In employee parking areas, 90 degree parking and two-way traffic can be used because employees are familiar with the facility and have a low parking turnover frequency.

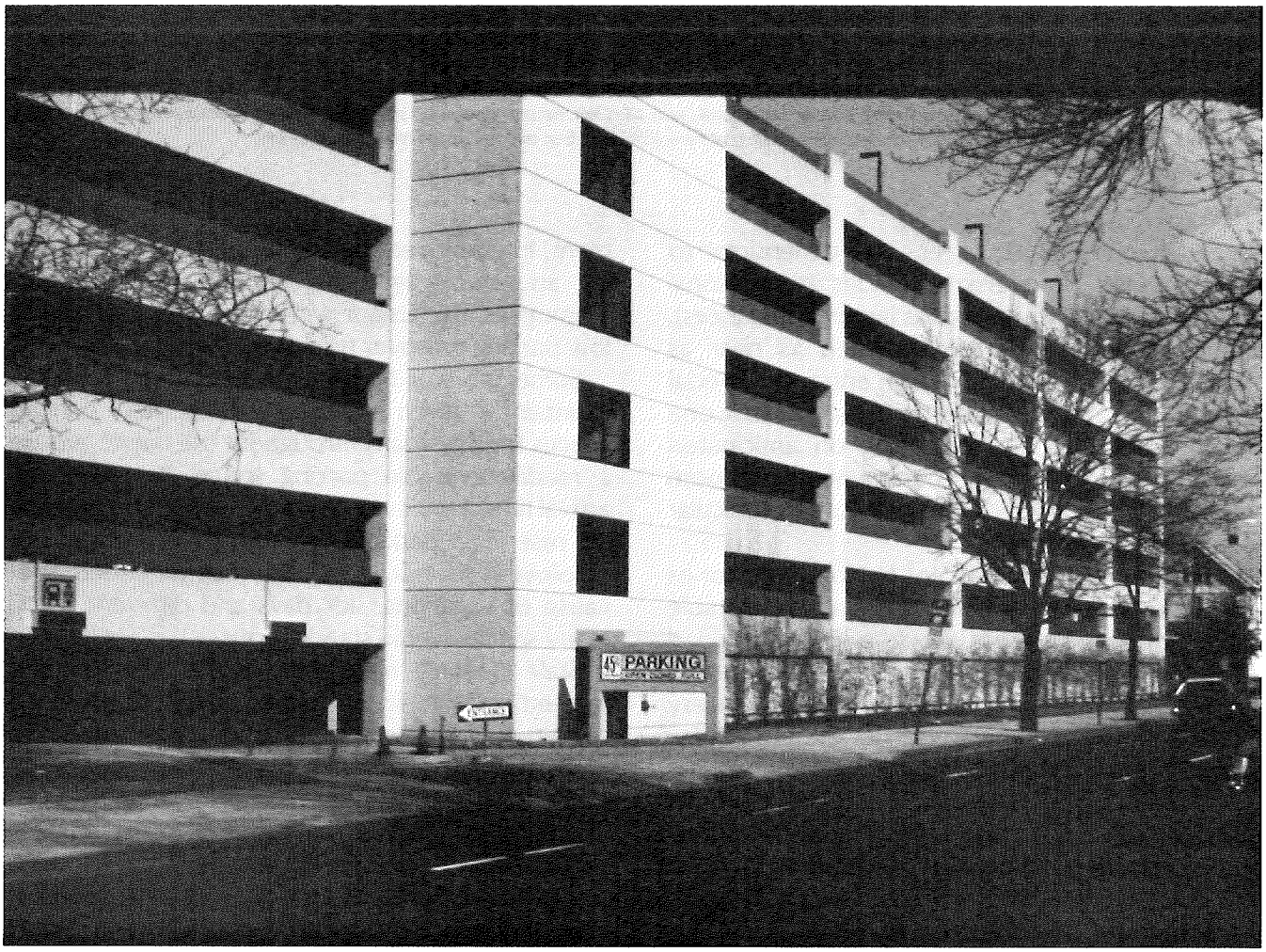
Some medical facilities, as a matter of policy, maintain a given number of reserved parking spaces for physicians throughout the day to ensure a readily available parking space, regardless of arrival time. However, as stated earlier, the practice of reserving parking for the exclusive use of employees is not generally recommended; because of vacations, sick days and different shifts, many spaces would stand empty.

Staff parking need not be as conveniently located or as generously sized as spaces provided for patients and visitors. Consideration should be given to requiring employees and staff to use the more remote, less convenient parking areas. Requiring evening shift employees to use an area separate from that used by the day shift, can help traffic flow during afternoon shift changes. For improved night-time security, consideration should be given to allowing evening and late shift employees to use parking areas near building entrances. Traffic flow in and out of a parking facility during peak demand periods can be regulated by the number of access points and how they are controlled.

Security is a particular concern for medical facility parking, since parking activity occurs around-

the-clock. Good lighting is the basis of a good security system. Security fences can be used to limit access to certain controlled points. Some medical facilities use security patrols and/or parking area surveillance systems.

Sound surveillance systems with two-way speakers can be used to monitor different areas in a garage sequentially. Panic buttons along pedestrian routes allow a person in danger to override the sequential order to alert security people. If video monitors are used, they should be in conjunction with an audio system. Glass elevators and stairwells open to the street should also be considered for security reasons.



St. Raphael Hospital, New Haven, Connecticut – this major medical facility has an 840-space parking garage allowing visitors direct access to hospital entrances.

CHAPTER III
COLLEGES AND UNIVERSITIES

There are over 3,200 institutions of higher education in the United States. In 1980, 11.7 million students were enrolled in these facilities. Locations of these institutions vary from high-density metropolitan campuses to large assemblages of land in suburban areas. The average institution has an enrollment of over 4,000 persons. Each varies in total population, from as low as 135 students at Cathedral College in Douglastown, New York to over 75,000 students at the University of Massachusetts in Boston.

For purposes of discussing and presenting statistical data, the term "university" includes both colleges and universities. The difference being a university generally contains a number of colleges; i.e., College of Fine Arts, and School of Medicine.

Planning for parking at universities offers a challenge. Each campus is unique in its environment and character and, like medical institutions, it is not accurate to formalize generalized planning factors for these traffic and parking generators without some detailed study.

In determining parking space requirements for universities, the specific characteristics and needs must be understood. In addition to being a major gathering place for students and visitors, the campus also serves as a place of employment; and it is a place of residence—for both students and staff. Many universities have large resident populations and, in some instances, require all students to reside on campus. At two-year institutions (community colleges), in contrast, the student is a daily commuter. Many universities also host sporting events and other types of activity that significantly affect campus parking needs. Parking for special event attractions is discussed in Chapter IV.

University parking space needs are affected by socioeconomic factors relating to the cost of education and the financial situation of the student/family. The number of students with a car available is much greater today than ever before. This adds to the need for convenient, affordable parking to serve the user, which in turn, serves the university.

Numerous factors should be addressed in the assessment of campus parking needs. Factors that should be considered include:

- What is the anticipated on-site student and staff peak visitation? How often does this occur?
- What is the modal choice opportunity for these persons? Who are the automobile drivers, and who ride as passengers or depend on a different travel mode?

- Are other modes of transportation available? How will availability of the alternate modes affect campus parking needs?
- What is the institution's policy on parking? Will parking be provided for all persons attracted to the campus, or restricted to certain groups?
- Is there a cost associated with the use of campus parking, and how does this affect modal choice?
- What is the student/staff distribution between residents and commuters?
- How many residents will require their personal vehicle on campus?
- What is the evening student population (student and staff)? Typically, evening students are more automobile oriented than day students.
- How will university sponsored sporting events and other special events affect overall parking needs?

Answers to these questions and analyses of specific characteristics determine the university's parking space needs.

Table X presents a summary of university population statistics between 1960 and 1979. In 1960, 1,968 colleges and universities existed in the United States, as compared to almost 3,200 in 1979. Total student enrollment increased from 3.58 million to 11.70 million in 1979, representing a tripling of student activity. The largest noticeable increase in student enrollment occurred in community colleges (institutions offering two-year programs) increasing from 450,000 students in 1960 to 4.25 million students in 1979.

Travel and Parking Characteristics

This research uses data from parking and traffic related studies conducted at over 30 United States' universities with detailed data observed at 16 universities. Other data were compiled from trip generation information presented in materials of the Institute of Transportation Engineers, as well as supplemental information sources.

The appendix and bibliography contain a summary of universities studied. The 16 specific case studies ranged in student population from 5,000 to about 26,000 students. Faculty/staff populations ranged from 600 to over 7,000 persons.

University Population

University population consists of faculty, staff, employees, students and visitors. In discussing parking space needs, the population categories are referred to as either students or staff. All faculty, staff, and non-student employees are identified as staff. It is important to identify students and student employees to avoid double counting.

University population is categorized into daytime and evening, resident and commuter students and staff. Evening classes are typically attended by part-time students. Daytime students are considered full-time students.

TABLE X – UNIVERSITY POPULATION TRENDS 1960-1979

Category	Year					
	1960	1965	1970	1975	1977	1979
Number of Institutions						
Four-Year	1,447	1,551	1,665	1,767	1,808	1,975
Two-Year	521	679	891	998	1,018	1,215
TOTAL	1,968	2,230	2,556	2,765	2,826	3,190
Number of Students[a]						
Four-Year (Millions)	3.13	4.69	6.29	7.22	7.24	7.45
Two-Year (Millions)	0.45	0.84	1.63	2.51	4.04	4.25
TOTAL	3.58	5.53	7.92	9.73	11.28	11.70
Number of Faculty[b]						
TOTAL (Thousands)	280	410	530	780	820	830

[a] Total student enrollment of the institution.

[b] Includes resident faculty of the institution.

Source: Statistical Abstract of the United States 1979 Edition. Selected Values from Table No. 263, 1960-1977. U.S. National Center for Education Statistics, 1979.

Travel Mode and Parker Accumulation

The arrival mode of staff and students is a key element in determining parking space needs. The percentage of students driving to the campus varies from as low as 10 percent to as much as 85 percent. This, alone, identifies the diversity in the number of parking spaces required by universities. Table XI summarizes the percentage of automobile drivers in the staff/student population at selected universities.

The percentage of students using an automobile that must be parked on campus varies between 16 and 79 percent. The higher value reflects an institution located in a suburban automobile-oriented area. Use of automobiles by staff is consistently higher than that of students (as a population percentage), largely because of the journey-to-work trip.

The peak-hour parking space requirement at universities is affected by arrival mode and person accumulation. Mode of arrival can readily be determined through surveys. The university staff/student person accumulation is comprised of classroom occupancy, number of persons using university services, including library, study halls, administrative services, recreational/social facilities, and facilities for special events. The accumulation of campus population is also comprised of persons transferring or moving between functions at different locations.

The commuter student's daily activity is influenced by the availability of classes and personal schedule. As a result, a student may complete daily classes by 11:00 AM or remain on campus for most of the day as a result of non-continuous classes and other campus activities. Thus, the peak parking space needs are developed based on the accumulation patterns of all on-campus persons and their modal choice and vehicle occupancy characteristics.

TABLE XI – UTILIZATION OF AUTOMOBILE AS MODE OF ARRIVAL (SELECTED UNIVERSITIES)

Study University[a]	Percent Auto Drivers	
	Staff[b]	Students[b]
Virginia	81	25
Texas	86	78
Massachusetts	67	38
Texas	69	47
California	95	79
Pennsylvania	57	16
California	70	52

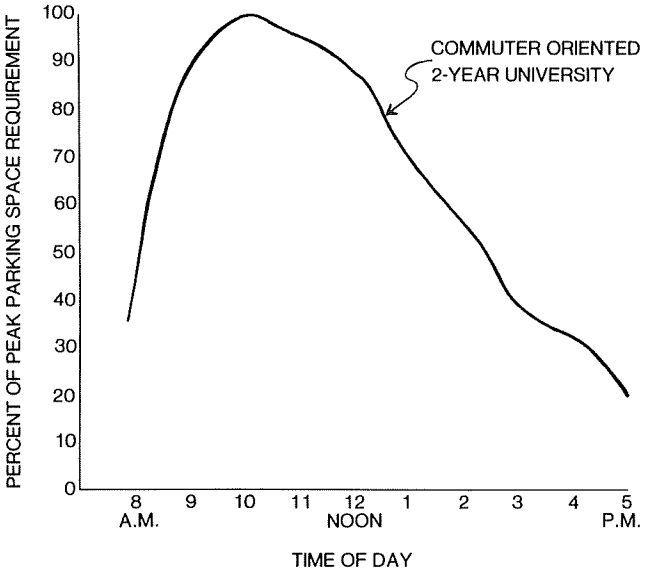
[a] See Appendix for individual universities.
[b] Excludes residents, where applicaable.

Accumulation Patterns of Student Parkers. Figure 13 shows student parker accumulation patterns for selected four-year universities having resident and commuter students. Both types of student demand require substantial amounts of parking in the morning and evening hours. This is evident at 5:00 PM when parking space needs for the commuter-generated demand represent 25 percent of the peak-hour parking requirement; whereas, the resident-student parking demand requires about 70 percent of the peak-hour requirement. This is a significant factor when considering the effect of evening parkers.

Figure 13 also shows the accumulation patterns of daytime student parkers at a selected two-year community college. The accumulation pattern curve for parkers at this two-year college is very similar to that of four-year commuter-oriented schools. The exception is during afternoon hours when fewer student parkers are at the two-year school due to outside job requirements.

Accumulation Patterns of Staff Parkers. Accumulation patterns of staff parkers including employees, faculty, and visitors are somewhat similar for all institutions of higher education. As shown in Figure 14, the peak-hour typically occurs during late morning hours (around 11:00 AM), and coincides with that of students. At 8:00 AM, staff parking demand is less than 50 percent of its peak parking accumulation. Parking activity for staff parkers peaks in the late morning and early afternoon hours and then gradually declines to less than 40 percent of peak accumulation at 5:00 PM.

Accumulation and Turnover Patterns of Campus Parkers. Figure 15 shows daily accumulation patterns for all parkers at selected universities. While commuter-student and staff parking space needs are relatively low at 5:30 PM, resident student parking needs are substantial and have a significant effect on evening parking space use. Resident-student parking space demands generally peak in the morning hours when most students are residing on campus. It then gradually declines throughout most of the day. This is because some



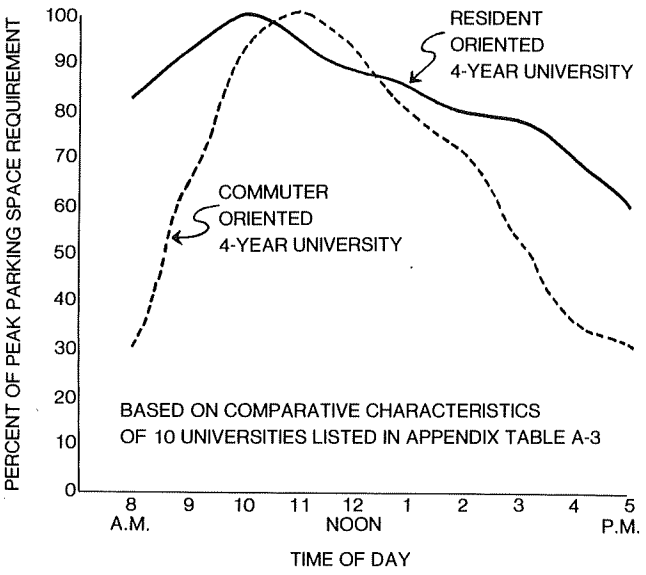


Figure 13. Accumulation patterns of daytime student parkers.

resident students use their car for recreational/work related trip purposes when not attending classes. Resident-student parking duration patterns are much greater than commuter students.

Universities experience a wide range of system-wide parking space turnover rates; from 1.3 at a resident-oriented university with no evening classes, to 4.0 parkers per space per day. This range is due to variable levels of student travel activity and academic nature of the school. Schools serving a large volume of commuter students experience higher turnover rates while resident-oriented campus experience less parking turnover.

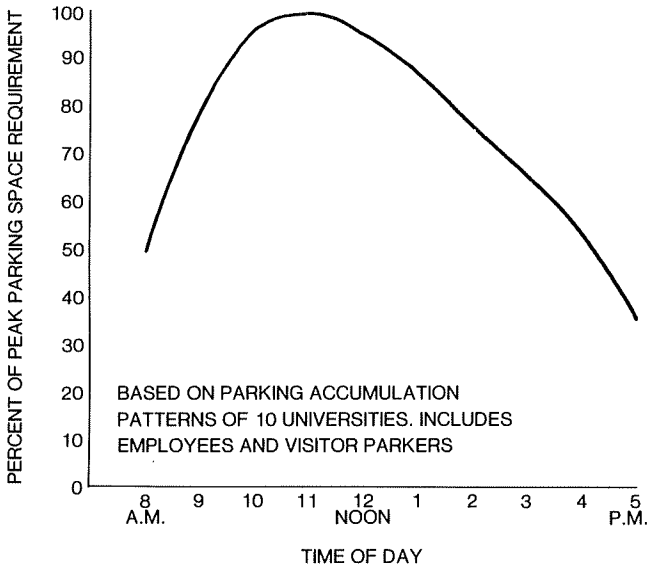


Figure 14. Accumulation patterns of daytime staff parkers.

Planning for Campus Parking

Most colleges and universities are major traffic generators, and they can have a tremendous impact on the traffic of their surroundings. Major institutions of higher education can generate as many vehicle trips per day as central business

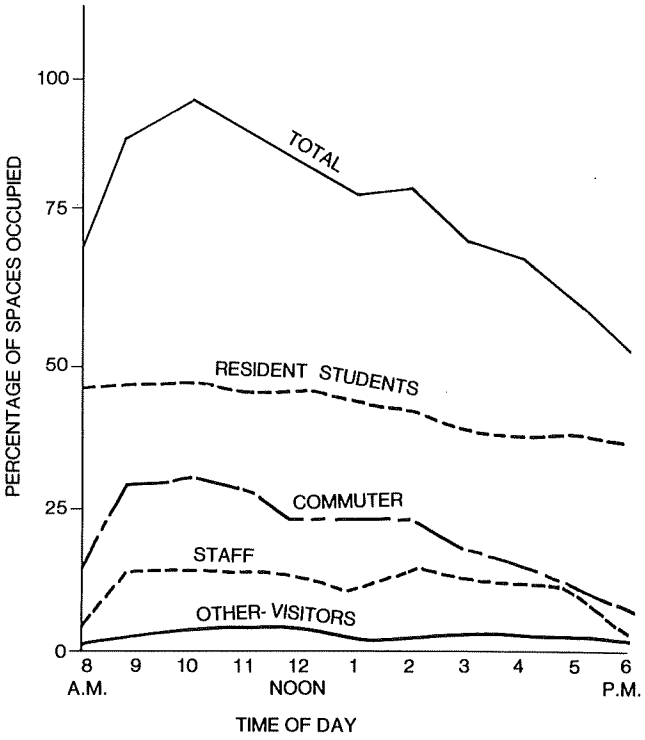


Figure 15. Daily accumulation of all university parkers.

districts in cities of comparable population. Because the campus is a large traffic generator, provision for vehicle parking should be coordinated with the institution's overall traffic planning, as well as that of the surrounding area. The campus should not be treated in isolation from its neighboring developments.

To accurately assess campus parking needs, it is necessary to determine travel mode and parker accumulation patterns, as well as traffic distribution and duration patterns for the specific campus attractions. Institutional policies regarding vehicle usage on campus will also affect parking needs.

Campus parkers represent a captive audience. Campus parking demands frequently exceed the parking supply, and since parking is typically subsidized, it behooves the institution to provide the most economical parking feasible. This often means less generous parking dimensions and fewer amenities – made possible by the familiarity of campus parkers with the available facilities, and the fact campus parkers are a captive audience. It also means that special attention must be given to parking regulation enforcement practices and parking facility design features that complement rather than complicate enforcement.

Determining Parking Needs

Campus parking needs depend on population characteristics, as well as other circumstances that shape the demand for parking. Many of the possible and differing circumstances affecting parking needs were listed as factors for consideration in the introduction to this chapter. These varying circumstances and characteristics are caused by differing administrative policies, campus locations, and socioeconomic factors. Only a relatively broad range of parking ratios can be presented. Parking ratios should be used for a comparison check against computed needs based on study of actual circumstances and characteristics at the given campus.

At major university campuses, specific buildings or areas may require an independent analysis of parking needs and, as a result, the total parking supply may exceed the combined overall parking demand of the campus. The total number of parking spaces necessary to meet the individual needs of each demand segment may be in excess of the combined peak-period demand for parking spaces on campus.

Staff Parking Space Needs. Staff parking needs vary from 0.50 to 0.95 parking spaces per daytime staff member. In comparing staff parking space needs to daily staff auto driver population, a range of 0.76 to 1.10 parking spaces per auto driver is required. Included in these values are visitor parking space needs.

Commuter-Student Parking Space Needs. Commuter-student parking needs are largely dependent on mode of arrival and peak-hour accumulation of persons. Campuses within a central business district, where transit service is available, require less parking than suburban campuses. Table XII presents ratios of the number of commuter-student parking spaces neeeded based on the total

TABLE XII – SUMMARY OF PARKING SPACE NEEDS RATIOS
(SELECTED UNIVERSITIES)

Study Institution	Number of Parking Spaces Needed per: Staff Daytime[a] Population	Number of Parking Spaces Needed per: Commuter Staff/Daytime[a] Auto Driver Population	Number of Parking Spaces Needed per: Daytime Commuter Students	Number of Parking Spaces Needed per: Daytime Student Auto Drivers	Number of Parking Spaces Needed per: Daytime Resident Students	Number of Parking Spaces Needed per: Daytime Resident Staff
A	–	–	0.27	0.34	–	–
C	0.70	0.79	0.23	0.27	–	–
D	0.62	0.76	0.44	0.59	0.23	0.84
E	0.61	1.07	0.13	0.77	0.15	–
F	0.49	0.59	0.29	0.37	0.40	–
G	0.55	0.84	0.33	0.69	–	–
H	0.95	1.09	0.21	–	0.22	0.98
I	0.90	1.10	0.37	–	–	–
N	0.50	0.75	0.13	0.34	–	–

[a] Includes Visitor Parking Space Needs.

commuter-student enrollment, as well as the auto driver commuter-student enrollment.

The range of parking space needs shown in the table for both commuter-student population types does not present a definite trend. The primary reason for this is the variance in the actual number of students on campus during the peak day (average daily attendance) and the number of those persons on campus during the peak hour. Table XIII presents average daily attendance factors and daily peak-hour accumulation values. These values are also widespread and it is the combined effect of these two factors that are essential in determining peak-hour student parking needs.

Resident-Student Parking Needs. Parking space needs for resident students vary but remain below 0.5 parking spaces per resident student. The ratios of parking spaces per resident student listed in Table XII merely present the diversity in parking needs. Parking space needs for resident students vary from 0.15 to 0.40 parking spaces per resident student. As administrative policies often inhibit the amount of parking, one parking space should be provided for each resident adjusted to reflect on-campus vehicle ownership. Typically, where administrative policies do not limit parking, about one space for every two resident students should be provided.

Parking Space Guidelines. The amount of parking space to be provided on campus should be individually determined for both the staff population category, as well as students. These categories should further be separated into resident and non-resident parking space needs. Table XIV presents a summary of the study values previously discussed. The ratio of the number of parking spaces per person is summarized giving the average value, as well as the low/high range. These values are presented for the total population, as well as for the auto-driver population. Parking space needs for commuter students average about 0.5 parking spaces per daily student auto driver. Parking needs for staff average 0.90 spaces per daily staff auto driver.

Figures 16 and 17 illustrate the range in the amount of parking space required for the daily staff

TABLE XIII – DAILY UNIVERSITY POPULATION CHARACTERISTICS

Study Institution	Average Daily Attendance Factors[a] (Percent)	Peak-Hour Accumulation Factors[b] (Percent)
A	49	76
B	51	–
E	80	67
F	55	72
I	–	42
K	76	–
M	75	–
N	49	79

[a] Values reflect the daily student commuter population expressed as a percentage of the total commuter enrollment (7:00 AM to 4:00 PM).
[b] Values reflect the peak-hour accumulation of commuter students expressed as a percentage of the daily commuter attendance.

TABLE XIV – SUMMARY OF UNIVERSITY PARKING SPACE NEEDS

Population and Category of Parking Space Needs[a]	Number of Peak-Hour Parking Spaces per Person
Total University Parking Space Needs	
Average Daytime Campus Population – All Persons	
Average	0.35
Range	0.15-0.60
Average Daytime Campus Population – Auto Drivers	
Average	0.50
Range	0.25-0.85
Student Parking Space Needs	
Total Daytime Commuter Student Population – All Persons	
Average	0.30
Range	0.05-0.50
Total Daytime Commuter Student Population – Auto Drivers	
Average	0.50
Range	0.15-0.80
Staff Parking Space Needs[b]	
Total Daytime Staff Population – All Persons	
Average	0.70
Range	0.50-1.00
Total Daytime Staff Population – Auto Drivers	
Average	0.90
Range	0.60-1.10

[a] Based on daily (7:00 A.M. to 4:00 P.M.) population values.
[b] Includes visitors and all employees.
Source: Based on analysis of data from 16 colleges and universities.

and student population, and the auto-driving population on campus as a whole. It is apparent that the unique and individual characteristics of each campus require in-depth study to determine parking space needs.

The relationship of parking space needs to average daytime population is shown in Figure 16. For a university with an average daytime population of 10,000 persons, between 1,800 and 5,200 parking spaces are required, assuming two-thirds of the average daily population are auto drivers. Figure 17 indicates that between 3,100 and 5,200 parking spaces should be provided. Thus, the range of parking space needs is reduced in Figure 17 However, the discrepancy remains relatively high due to variances in peak-hour accumulation characteristics, resident population, and administrative policies.

In order to increase the confidence level of these values, definite characteristics of each university should be used to define parking needs. The formula for calculating the parking need is as follows for each population category.

Commuter Student Parking Space Need = P · C · W · F · A

where:

P = total daytime student population
C = percentage of commuter students not considered as part of the staff or faculty
W = percentage of total population expected to arrive on a peak weekday
F = peak-hour accumulation factor for on-site students using autos
A = percentage of commuter students arriving as auto drivers.

The formula for staff parking space needs is identical in respect to the derivation of number of required spaces. The total calculated for staff parking needs should be increased by about 10 percent to provide adequate visitor parking spaces. All calculations should be made in consideration of the specific location of the generator to be served.

The difficulty in using these formulae is the derivation of the W and F values. Constant change in curriculum and university growth can significantly affect average daily attendance (W). More difficult, however, is the determination of the F value peak-hour accumulation factor.

Derivation of the F value must consider a determination of the maximum number of persons on campus at a given time, including staff, students attending classes, student employees, students using on-campus facilities, and those students in transition between activities.

Financial Considerations

Few universities charge for parking in the conventional manner of issuing a ticket and collecting a daily or monthly fee. Most university parking facilities are controlled by a parking identification sticker program. Stickers are issued to staff (on an annual basis) and students (on a semester basis).

Typically, a nominal fee is charged for university parking. A $10 to $25 charge per semester for university parking is common, and in some instances parking is not an itemized expense to the student or faculty member.

Most university parking systems are subsidized through tuition fees and school endowments. Table XV presents an analysis of daily revenues required to offset parking costs. For 1981 conditions, approximately $0.95 per day is required to offset the cost of constructing and operating university parking in the form of a surface lot. A daily per space revenue of about $4.15 would be required to break even assuming an above grade parking garage. This cost increases to over $6.00 for the provision of underground structure parking. These costs are based on an average of 250 annual operating days for a campus parking facility, excluding land costs.

Assuming a typical daily turnover rate of about 3.0 parkers per space per day (combined daytime and evening parkers) the following average daily charges would have to be applied in order to pay the actual costs of providing parking space in the 1981 market.

ESTIMATED COST PER PARKER BY TYPE OF PARKING

	Surface Lot	Above Grade Garage	Below Grade Garage
Estimated average daily parking charge	$0.30	$1.40	$2.00

The typical staff and student parker would be required to pay about $0.30 per day for surface parking and $1.40 per day for above-grade structured parking. This would result in an average cost of about $30.00 to $140.00 per semester for spring

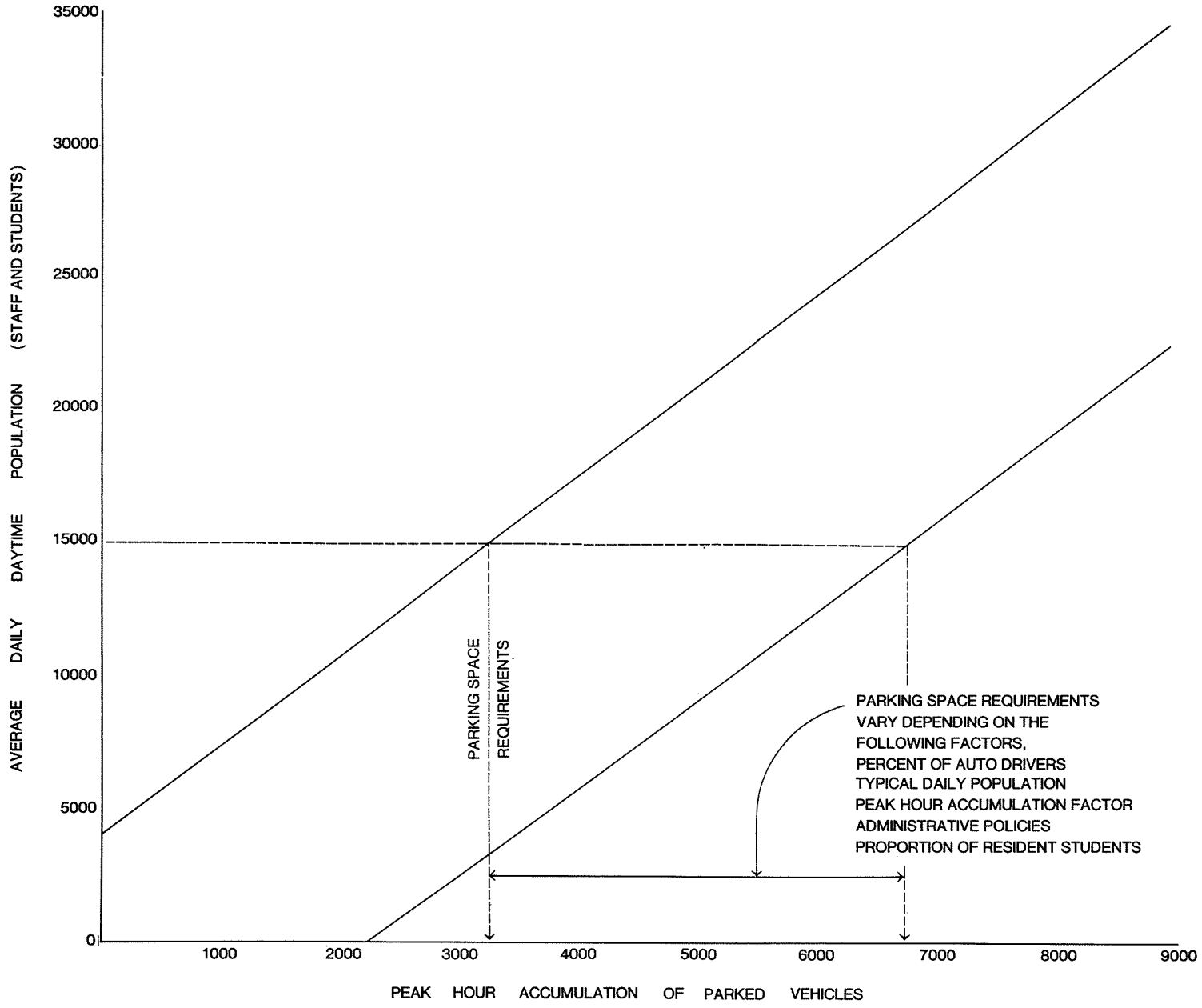


Figure 16. Peak-hour parking space needs of universities as compared to average daily population

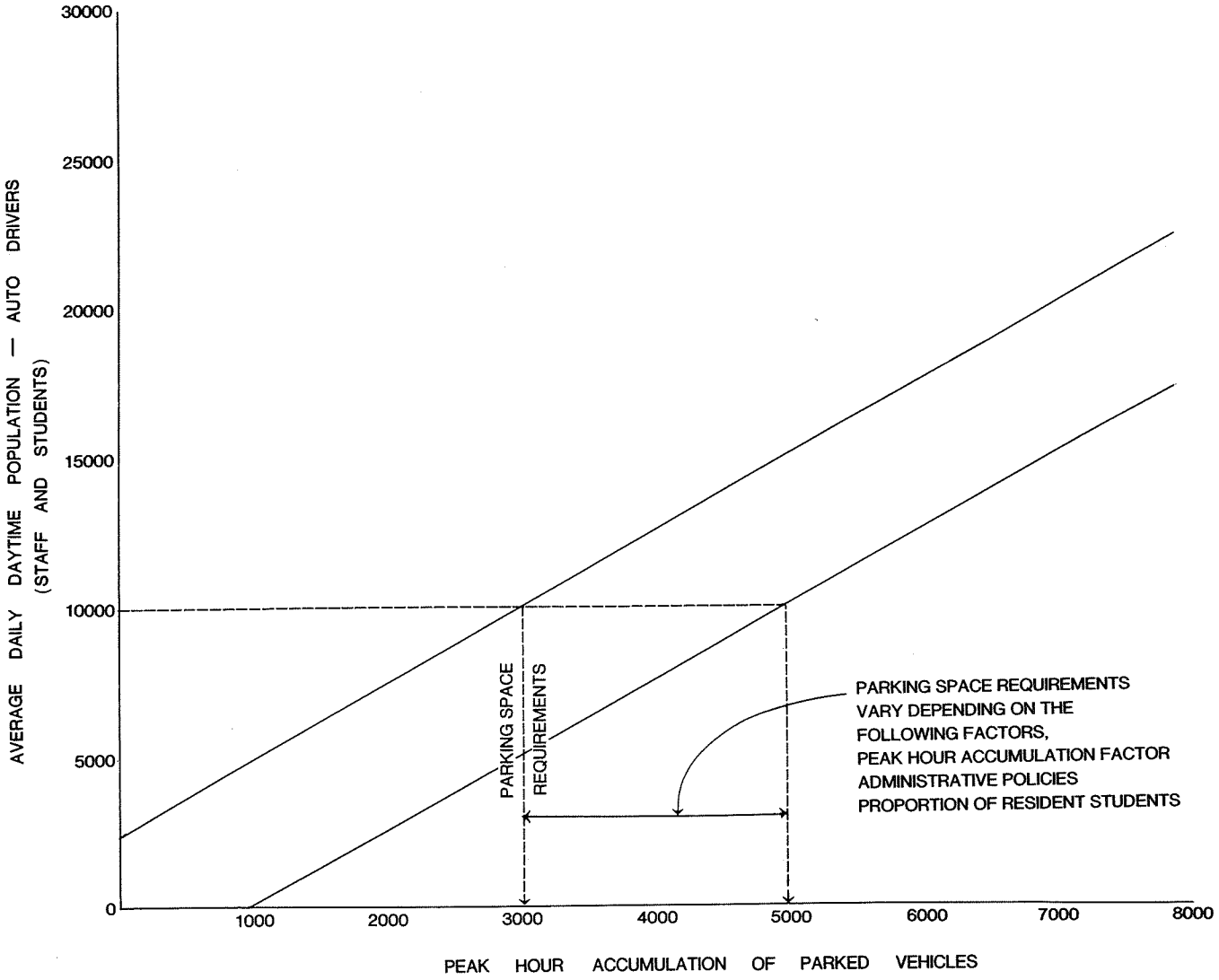


Figure 17. Peak-hour parking space needs of universities as compared to daily auto driver population.

TABLE XV – FINANCIAL CONSIDERATIONS OF UNIVERSITY PARKING SYSTEMS

Item	Estimated Per Space Calculations		
	Surface	Above Ground	Below Ground
Estimated Construction Cost[a]	$1,200	$6,000	$ 9,000
Estimated Total Development Costs[b]	1,500	7,500	11,200
Estimated Annual Debt Service[c] Tax Free Financing @ 11 percent	175	865	1,300
Estimated Annual Operating Costs[d]	60	175	225
Total Annual Expenses	235	1,040	1,525
Required Per Space Income Per Operating Day[e]	$0.95	$4.15	$6.10

[a] Values reflect comparative cost of the three types of parking assuming compatable amenities. Land costs are excluded from these figures.

[b] Includes design fees, financial-legal fees, insurance during construction, capitalized interest during construction at 11.0 percent and interest on investments received for the construction fund.

[c] Based on a 30-year bond, level debt service payments over a 29-year amortization period.

[d] Based upon a conventional university parking operation including all other normal operation expenses: such as maintenance costs, utilities, insurance, supplies and enforcement. Excluded from these costs are administration expense, and management fees.

[e] Based on 250 days of operation.

and fall students/staff and $15.00 to $70.00 for summer students/staff. As a result of these costs the university is faced with either subsidizing parking or creating a condition whereby students will seek other locations for less expensive parking, or other travel modes. Thus, where high costs of parking exists or where there is insufficient parking capacity, students compete with other areawide parkers for less expensive and often free curb parking, creating an off-campus parking problem.

Functional Design Considerations

Campus parking should be sited as near as possible to major buildings and activity centers. Walking is the major form of campus travel, and special attention should be given to pedestrian connections between parking areas and campus attractions. These location considerations, however, can conflict with other considerations to control vehicular traffic movement on the campus. To minimize vehicular traffic penetration of the campus, parking areas should also be sited to intercept traffic at points where principal traffic flows enter the campus, reducing unnecessary circulation on campus streets.

Parking for resident dormitory students has historically been provided on the campus periphery. Today, many university administrations are recognizing the increasing student demand for parking near their place of campus residence. More students now feel a need for their cars on a routine basis. Periphery parking areas (storage lots) should still be considered for resident students who do not need their car on a routine basis or have restricted use of a vehicle because of administrative policy. At some universities peripheral parking areas in conjunction with shuttle transportation has been used for commuter students and staff, but this concept has not enjoyed widespread success.

Since students and staff are familiar with campus parking facilities, 90 degree parking with two-way traffic movement can often be used to maximize area efficiency. For safety and convenience reasons, angle parking and one-way traffic aisles may be more desirable for campus parking areas catering to visitors or short-duration parkers.

CHAPTER IV
SPECIAL EVENT PARKING

Special event parking, unlike other parking, is usually generated by social-recreational activities attracting large assemblages of people. Special events generate parking demand at stadiums, convention centers, auditoriums, and exhibition halls. Additionally, huge parking demands can be generated by special events occurring almost anywhere; from PGA golf tournaments held at local country clubs to annual civic sponsored festivals that can extend over blocks of city streets.

Attraction of people to special events depends largely on an individual's leisure time, and as a result, events are often held during evening and weekend hours to avoid conflict with normal working hours. Most regularly scheduled professional sporting events, for example, are held on weekends and during weekday evenings. Even though convention/exhibition centers and certain other special event generators may have many weekday daytime attractions, peak attendance usually occurs during evenings and on weekends. There are exceptions, such as the business oriented convention, normally scheduled for weekdays and extending over one or more days. Frequently, if not typically, peak attendance occurs during the work-day hours for this type of special event.

The very nature of a special event can cause traffic and parking problems. While there are exceptions, most special events attract crowds that arrive over a 60 to 90 minute period, and when the event concludes, the crowd leaves – typically, all at the same time. Even with special purpose facilities, designed to accommodate special events, the rapid build up of people and their machines, and their more sudden departure after the event, creates potential traffic and parking problems. If the special event is to occur at a location not specifically designed for such events, associated parking and traffic demands can easily become a severe problem. To prevent or minimize special event traffic and parking problems, the key is smart advance planning.

Special Event Parking Characteristics

The parking demand characteristics of special events vary greatly because of the differing nature and location of events. Parking demand characteristics for special events are reflected by mode of arrival used and vehicle occupancy, which are largely dependent on the type of event and its location.

Travel Mode

Use of the private vehicle as an arrival mode to special events depends on the events's location. Cost of parking, the available parking supply, and

the existence of transportation alternatives are the principal factors of location influencing travel mode.

As shown in Table XVI, private vehicle usage to professional baseball games at New York City's Yankee and Shea Stadiums represent 40 and 65 percent of the total trips compared to an automobile usage of nearly 100 percent at the same type of event held at Anaheim Stadium in California.

Vehicle Occupancy

Vehicle occupancy factors vary by type of event. Activity at major league football games, for instance, average 3.0 persons per private vehicle. Private vehicle occupancy for major league baseball is slightly lower, averaging 2.5 persons per vehicle. Table XVII summarizes these values.

Planning Considerations for Special Event Parking

Crowd-generating events occur at either special purpose facilities with permanant parking arrangements or at less formal locations that must depend on temporary arrangements. Parking needs must be determined and provided at both types of

TABLE XVI – MODE OF ARRIVAL TO VARIOUS SPECIAL EVENTS

Location	Type of Event	Percent of Persons Arriving by Private Vehicle
Oakland, California[a]	Pro-football	88
	Pro-baseball	97
Shea Stadium, New York[a]	Pro-football	65
	Pro-baseball	65
San Diego, California[a]	Pro-football	85
	Pro-baseball	97
Yankee Stadium, New York[a]	Pro-football	10
	Pro-baseball	40
Anaheim Stadium, California[a]	Pro-baseball	100
	Football	100
Atlanta Stadium, Georgia[a]	Pro-football	66
	Pro-baseball	87
Dodger Stadium, California[a]	Pro-baseball	85
Los Angeles Coliseum, California[a]	College Football	95
	Pro-football	90
Nets Stadium, New Jersey[a]	Pro-basketball	90
	Concert	70
Kansas City, Missouri[a]	Pro-football	60
Edmonton, Canada[a]	Pro-football	50
	Soccer	80
Mile High Stadium, Colorado[a]	Pro-football	82
	Baseball	100
Orange Bowl, Florida[a]	Pro-football	73
	College football	78
	High School football	75
Cotton Bowl, Texas[a]	Pro-football	82
	College football	87
Ohio State University, Ohio[a]	College football	84
Weber State, Utah[a]	College football	75
Ware Memorial[a]	College football	73
Memorial Stadium, Pennsylvania[a]	College football	68
Meadowlands, NJ[b]	Horse Racing	80
American Museum of Natural History, NY[b]	Museum	73
Hagley Museum, DE[b]	Museum	49
Milford, CT[b]	Jai Alai	88

[a] Traffic Engineering Magazine, June, 1975. Technical Council Committee Report 6A5.
[b] Wilbur Smith and Associates' Studies.

TABLE XVII – PRIVATE VEHICLE OCCUPANCY CHARACTERISTICS BY TYPE OF SPECIAL EVENT

Type of Event	Average Number of Persons per Private Vehicle
Museum	3.0
Jai Alai	3.0 (Evening/Weekends) 2.2 (Daytime-Weekdays)
Horse Racing	2.5
Professional Football	3.0
Professional Baseball	2.5
College Football	3.0
Basketball/Hockey	2.3
Professional Entertainment/Concert	3.0

special event locations based on a design crowd determined from estimated peak and average crowds.

Parking at Facilities Intended for Special Events

Most special event facilities are developed to host more than one type of attraction. Many stadiums, for instance, are used for baseball, as well as football games, and may even be used for occasional events not related to sports, such as concerts or other activities that are expected to draw large crowds. When planning a special event facility intended for multiple uses, the largest crowd/vehicle generating *regular* event should be the basis for parking provisions. Baseball, for example, typically does not attract the crowds per game that football games do, except for a World Series, which is too occasional to predict. Thus, parking football spectators would be more critical to planning considerations than parking baseball spectators at a stadium that is to regularly host both event types.

Location is the prime concern for a proposed facility intended to serve one or more types of special events on a frequent basis. Access and egress to the facility is extremely important in selecting a location. Facilities for events that attract very large crowds may require substantial regional roadway capacity to accommodate surge-type vehicle arrivals and departures of extreme magnitudes. Thus, providing adequate space for parking is only part of the solution to minimize special event parking problems.

After a special event ends, the time required for parkers to leave the facility in their vehicles is called the "dump time." Dump time is a critical concern in developing parking systems for special event facilities. Adequate external roadway and parking area exit capacity should be provided to enable all accumulated vehicles to disperse within 60 minutes.

If the special event facility is to be located in a central business district, there may be a possibility of using existing parking facilities to satisfy some portion of anticipated parking needs. Since most special events do not coincide with normal peak-hour traffic and parking demands, the use of existing parking spaces is a viable consideration.

A convention center constructed in downtown Buffalo, New York, was located near three existing municipal parking facilities. As shown in Figure 18, these three facilities are over 90 percent occupied during the major portion of normal working hours. However, when convention center activities peak during evenings and on weekends, less than 20 percent of the spaces are occupied. The availability of about 4,400 public and commercially operated parking spaces (see Figure 19) within 1,200 feet of the convention center (3,000 of which are within 600 feet) enabled this convention center to be constructed without additional parking.

Most special event parkers will accept walking distances ranging up to 1,500 feet between parking space and nearest destination entrance. Walking distances exceeding 2,000 feet are not uncommon for the most remote parking at special event facilities that regularly host crowds in excess of 45,000.

The number of parking spaces provided for selected stadiums across the United States are summarized in Table XVIII. Stadiums within central business districts and/or in close proximity to public transit provide one parking space for every 7 to 16 seats (less than 0.15 parking space per seat). Where good transit service or an existing parking supply is unavailable, one parking space for every two seats may be provided (0.47 parking space per seat).

For proposed, as well as existing special event facilities, remote parking with shuttle-bus operation may offer a partial solution for parking and traffic problems. Arrangements for the use of available and strategically located parking/bus pickup areas are usually formalized between the special event facility operator, the bus operator, and the parking

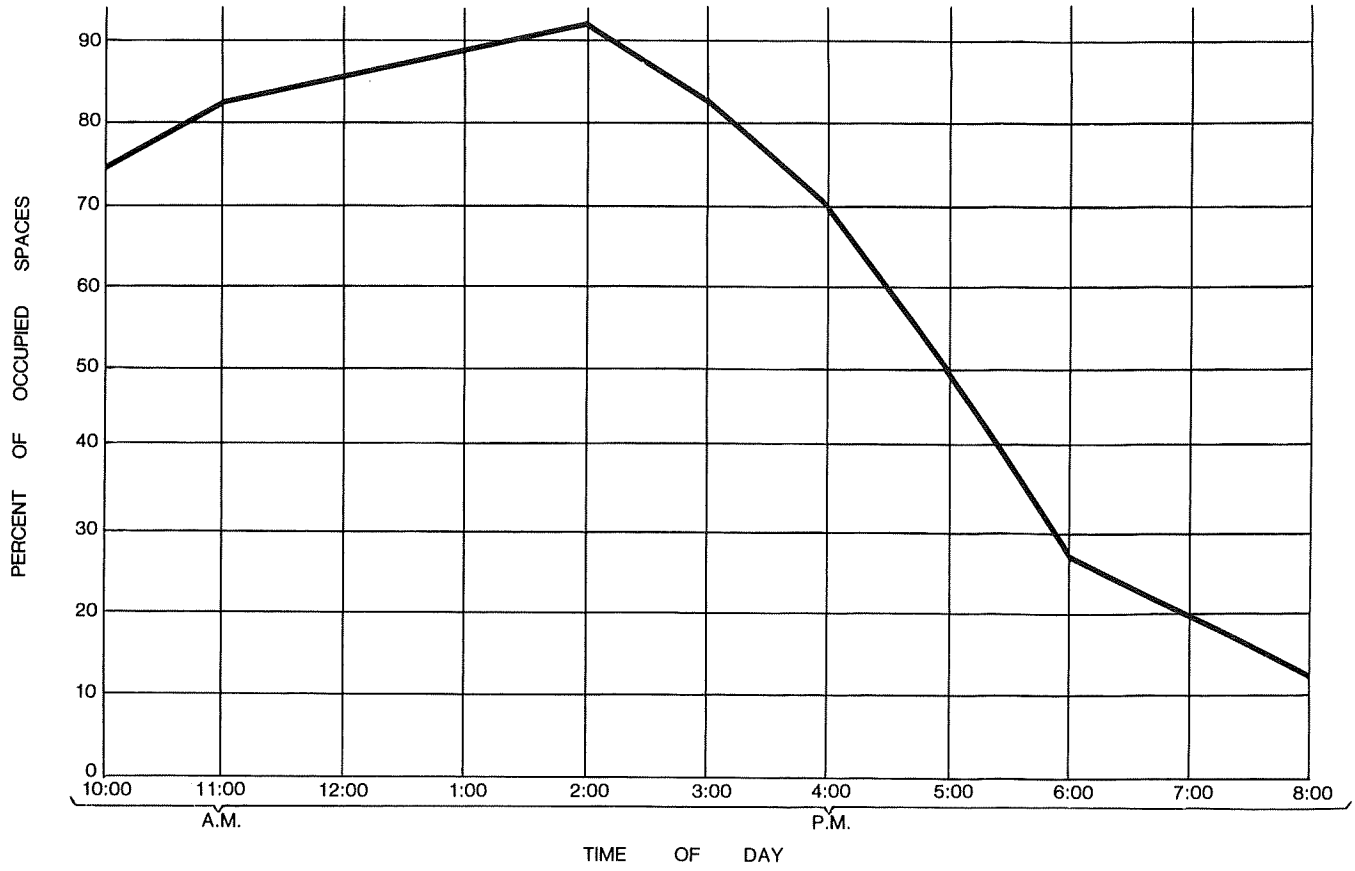


Figure 18. Typical weekday accumulation of parked vehicles, Convention Center Parking Study Buffalo, New York. Source: Wilbur Smith and Associates.

space supplier. Consideration must be given to recouping associated operation and promotion costs.

Financial Considerations. Special event parking typically exhibits a turnover rate of less than 1.0 parker per space per event day. For example, New York's Yankee Stadium in 1980 had a total attendance of 2.6 million persons with average attendance per event of 32,000 persons and a seating capacity of 57,500 persons. Assuming a direct relationship between attendance and automobile usage, with a parking supply that accommodates peak attendance, an average turnover would be 0.70 vehicles per space per event. Table XIX presents estimated revenue per space required to offset costs of parking based on 1981 dollars. Costs associated with surface parking would require a parking income of $1.65 per space per operating day. Structured parking would necessitate a per parking space charge of $6.85 for above grade and $10.10 for below grade parking. Based on an average turnover rate of 0.70 parkers per space per event day, parkers would have to pay from $2.00 for surface parking to about $8.50 for an above grade parking garage in order to offset annual expenses. If below grade parking is provided, a parker would have to pay over $12.50 to offset parking facility expenses. Land costs are not included in these calculations. As a result, special event parking operations are often subsidized by the special event's admission charges.

There are possible benefits in locating a special event facility within a central business district. Costs associated with parking development may be reduced if the facility can be located in close proximity to an existing parking supply, not having concurrent parking demands. In addition, special event facilities located in a central business district can strengthen the financial position of an existing municipal parking system with the additional revenue generated by special event parkers. Typically, there is more available street (traffic-handling) capacity serving central business district locations than at most rural, isolated sites.

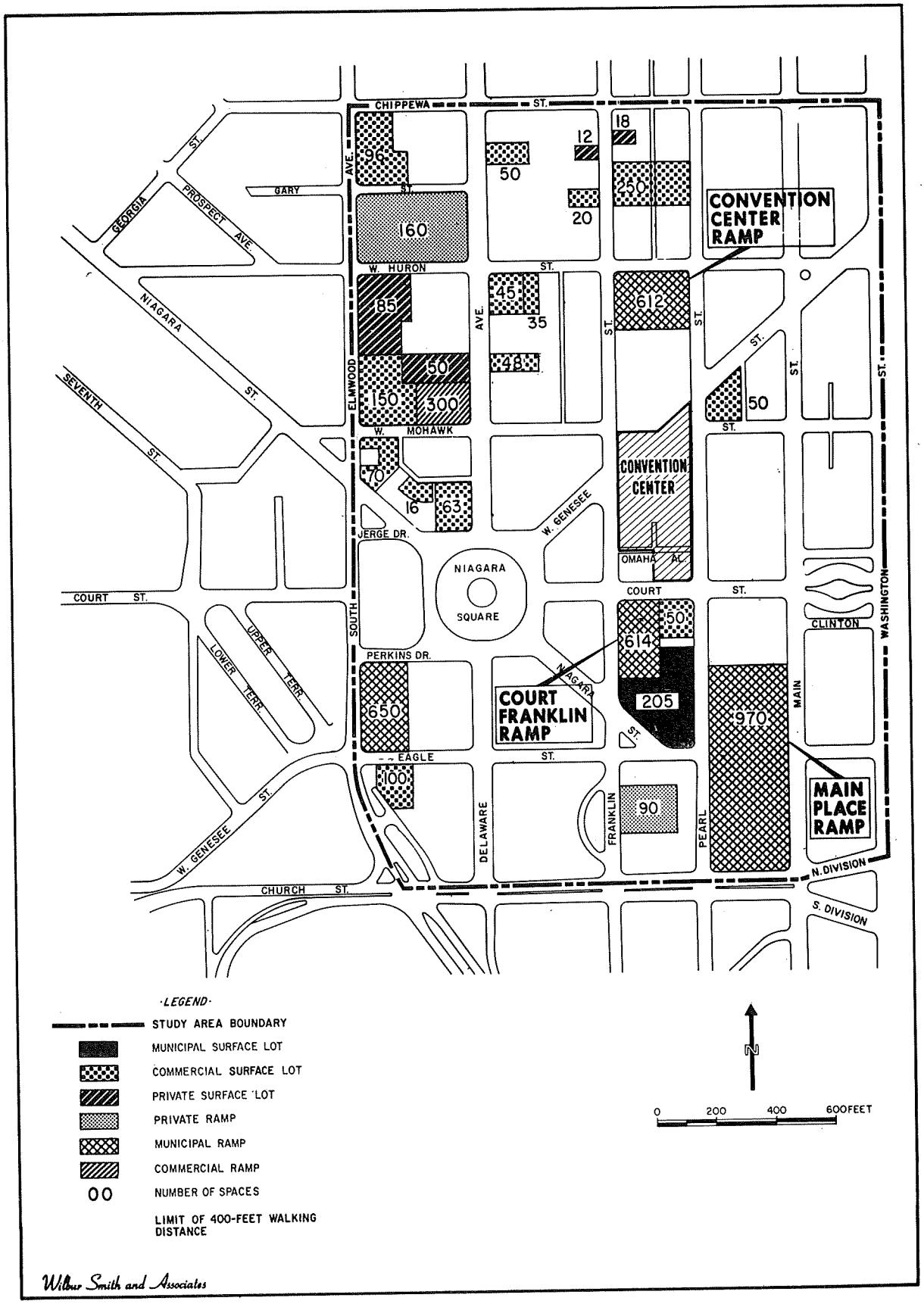


Figure 19. Inventory of off-street parking facilities, Convention Center Parking Study Buffalo, New York. Source: Wilbur Smith and Associates.

TABLE XVIII – COMPARISON OF PARKING SPACES AT SELECTED STADIA

Stadium	Seating Capacity	Number of Parking Sapces Provided by Stadium[a]	Number of Parking Spaces per Seat
Riverfront	56,200	4,550	0.08
Atlanta, GA	58,850	4,000	0.07
Shea Stadium, NY	55,000	7,400	0.13
Philadelphia Veterans, PA	65,300	11,000	0.17
Orchard Park, NY	80,000	15,000	0.19
Houston, TX Astrodome	53,000	25,000	0.47
Giants, NJ	76,000	20,800	0.27
Dodger, CA	56,000	16,000	0.28
R. F. Kennedy, D.C.	50,000	10,000	0.20

[a] Excludes other available parking facilities.

Functional Design Considerations. Special event parking facilities should be designed to minimize dump time. Given an external roadway system with adequate capacity, dump time will depend on the internal design of the parking complex.

Since most types of special event crowds leave simultaneously, and there is little or no demand for traffic movement in an opposing direction, reversible driving aisles and access points should be considered. Reversible direction driving aisles allow space-efficient 90 degree parking layouts, with the simplicity and safety advantages on one-way traffic that is normally associated with less space-efficient angle parking. When reversible traffic operation is contemplated, consideration should be given to access for emergency vehicles.

TABLE XIX – FINANCIAL CONSIDERATIONS OF A STADIUM PARKING SYSTEM

Item	Estimated per Space Calculations		
	Surface	Above Ground	Below Ground
Estimated Construction Cost[a]	$1,200	$6,000	$ 9,000
Estimated Total Development Costs[b]	$1,500	$7,500	$11,200
Estimated Annual Debt Service[c] Tax Free Financing @ 11 Percent	$ 175	$ 865	$ 1,300
Estimated Annual Operating Costs[d]	$ 70	$ 160	$ 210
Total Annual Expenses	$ 245	$1,025	$ 1,510
Required Per Space Income Per Operating Day[e]	$ 1.65	$ 6.85	$ 10.10

[a] Valves reflect comparative cost of the three types of parking assuming compatable amenities. Land costs are excluded from these figures.

[b] Includes design fees, financial-legal fees, insurance during construction, capitalized interest during construction at 11.0 percent and interest on investments received for the construction fund.

[c] Based on a 30-year bond, level debt service payments over a 29-year amortization period.

[d] Based on a conventional operation including cashier labor cost, and all other normal operating expenses. Excluded from these costs are administration, and management fees.

[e] Based on 150 event days.

Directional signing should be provided as necessary within parking areas, as well as along connecting access routes. The magnitude and concentrated nature of special event traffic, however, typically requires a greater reliance on traffic-directing personnel than other types of parking generators. Entrance cashiering, whereby fixed parking fees are collected as parkers arrive, is usually the best means of collecting parking fees at special events.

Loading and parking areas should be provided for charter buses. Bus use by out-of-town groups and remote parkers may generate several hundred buses at some events. Larger recreational vehicles, such as motor homes, are popularly used as a mode of travel to some kinds of events. A segregated parking area should be designed and reserved for these vehicle types.

Separation of pedestrian and vehicular movements should be achieved whenever possible because of the large volume of pedestrian traffic generated by special events. Pedestrian-vehicular separation measures such as walkways, bridges, and tunnels increase costs and require more space, however, specially constructed pedestrian ways may reduce walking distances, as well as increase safety. Directional signing for pedestrians should be

provided that enables parkers to easily identify the area in which they have parked.

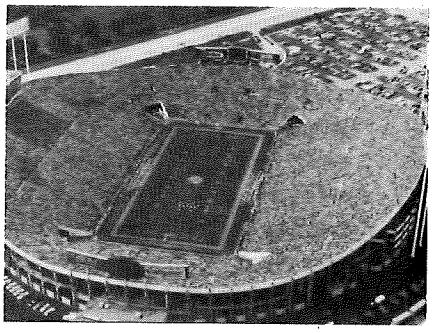
Temporary Parking for Special Events

Special events that occur on a one-time or occasional basis, where a special facility is non-existent or grossly inadequate, require temporary arrangements to handle traffic and parking demands. It is of paramount importance to plan for such events far enough in advance to allow arrangements to be made to park vehicles temporarily.

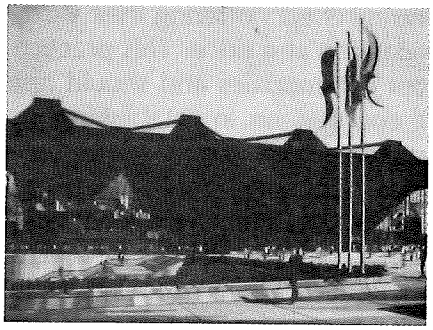
Special arrangements should be based on the anticipated parking and traffic characteristics likely to result for the type of event, expected crowd, and location or area that will host the event. A community festival, for instance, may be characterized by vehicles arriving and departing throughout the event's duration. In contrast, an air show may have far different parking and traffic characteristics – a one-time affair in and out.

Estimated parking needs can be satisfied by using a combination of (1) existing parking supply having non-concurrent parking demands, (2) remote parking with shuttle bus operation, and (3) unimproved areas suitable for temporary parking. Potential parking areas should be selected in regard to their accessibility. A special event may necessitate temporary vehicular traffic detours, on-street parking prohibitions, or other restrictions affecting potential parking sites. Parking on roadway shoulders or streets with insufficient width or without walkways should be prohibited and enforced. If pedestrians are encouraged or forced to walk in roadways, they are endangering themselves and impeding vehicular traffic flow. Where special event parking is inadequate and/or inconvenient, nearby property owners may decide to become one-day parking entrepreneurs offering their yards and driveways for parking at a price. This practice is prohibited in most communities and should not be encouraged or counted on in establishing an adequate parking supply.

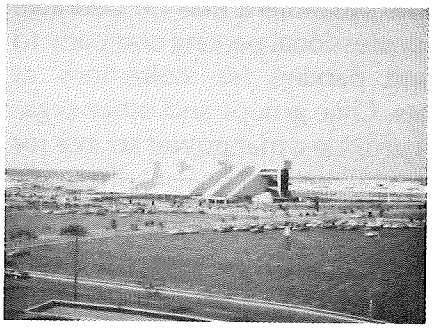
Planning for special event parking should encompass details for making and erecting appropriate standard signs to advise motorist where and where not to park. Contractural agreements for privately owned parking must be made far in advance of the actual event. In some situations it may be desirable to contract with a professional parking company to handle parking and parking fee collections at specific parking sites. Civic groups and other organizations can often provide a manpower source for directing parking operations and policing the parking areas of trash after the event concludes.



Tampa Stadium Complex, Tampa Bay, Florida – home of the National Football League's Tampa Bay Buccaneers – accommodates all sports and special events with approximately 72,000 seating capacity.

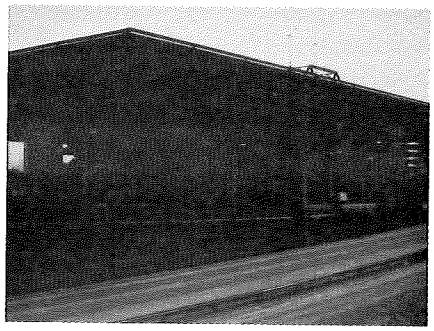


Omni Arena, Atlanta, Georgia – an arena coliseum accommodating all sports and special events with approximately 15,000 seating capacity.



Meadowlands Racetrack, Hackensack Meadowlands, New Jersey – features horse and harness racing with a seating capacity of approximately 12,000.

Teletrack, New Haven, Connecticut – features off-track betting while viewing horse racing on a movie screen.



New Haven Veterans Memorial Coliseum, New Haven, Connecticut – accommodates all sports and special events with approximately 10,000 seating capacity and a 2,400-space parking garage situated over the arena on four levels.

CHAPTER V
GENERAL PLANNING CONSIDERATIONS

The role of a proposed parking facility should be clearly identified early in the planning process. Preliminary planning should include an examination of factors pertaining to anticipated patterns of use, possible development sites and accessibility, as well as policy implications and resource requirements affecting parking facility development and operation. These factors should be examined in regard to current circumstances and to possible changes within the facility's life-time. Table XX outlines many of the factors that should be considered, regardless of generator type.

Success of a parking facility depends largely on its ability to satisfy parking demands with respect to parker characteristics. The gathering and analysis of essential data is most effectively done at the outset in the form of a feasibility study. Using field surveys as a primary information source, the study should reflect the many disciplines that affect parking facility development decisions. The feasibility study may vary from a few pages to a substantial volume; fundamentally, however, it should contain pertinent facts relating to the considerations in Table XX. A feasibility study is particularly useful to inform the community or institution's administration of the reasoning behind proposed solutions to parking problems.

In planning a parking facility of any type, one of the most critical considerations is the functional design. While function is a consideration with all facilities, it assumes more importance in a parking garage than in most building types. Parking structures and lots have unique functional requirements that must be met if the facility is to fulfill its role. That role is not merely to store vehicles, but also to process them and their passengers.

Parking Efficiency

Given enough space and unimpeded access, it is comparatively easy to park any given number of vehicles. These ideal circumstances, however, are seldom reality. As the size of parking facility increases and its traffic activity occurs over a shorter time period, the potential for operational problems increases proportionately. Small inadequacies in the physical layout and/or minor inefficiencies in the operation, can cause problems in any size parking facility; but, these problems can become magnified to horrendous proportions in large facilities under heavy traffic conditions. An inefficient parking facility can cost more than it should to operate, and cause parker dissatisfaction having unwanted economic implications for the generator(s) being served by the parking. An inefficient parking facility can also be dangerously unsafe.

Certain parking facility inadequacies, for exam-

TABLE XX – PRELIMINARY PLANNING CONSIDERATIONS FOR PARKING FACILITY DEVELOPMENT

Patterns of Use

Who and how many parkers will use the parking facility?
Will parking be on a short or long-term basis?
Will trucks or other large vehicles need to be accommodated?
How will daily and seasonal parking demand variations be handled?
What are the needs of special user groups?
How much pedestrian traffic will be generated and what are their needs?
Will night parking present special needs and/or security measures?
What level of convenience in terms of parking geometrics and walking distance should be provided?

Accessibility

Where will the parkers come from; are surrounding street and arterial capacities adequate for present and future traffic needs?
Are any alterations in the external access system proposed or being discussed?
Will there be additional or special directional signing needs along access routes?

Site Availability and Restrictions

What sites are available for parking development?
Once developed for parking, what are the possibilities the site will be needed for a different use in the future?
Is the site adequate in size and location to effectively serve parking needs?
Will existing or proposed nearby developments provide non-concurrent parking demands that might affect parking capacity requirements or the use of proposed parking spaces?
What provisions are necessary for pedestrians?
Are there topographical or sub-surface features that will cause development problems, or that can be of advantage to the parking facility?
How will the site's location in regard to its surroundings affect security needs?
What will be the environmental impact in regard to drainage; traffic attraction (particularly noise, congestion, and safety); dispacement of existing development and/or natural features; adjacent properties (particularly spillover lighting and disruption of visual vistas); and during construction?
What esthetic measures will be necessary to blend a parking facility on the site with natural features as well as with existing and proposed development?
How will site development be affected by local zoning/building regulations and existing easements that may cross the site?
Is parking facility development at the site compatible with master plans?
What will it cost to develop the site for parking?

Policy and Resources

How will development costs be financed?
How will costs of operation, maintenance, and eventual replacement be financed?
Are parking facility expenses to be repaid to some extent by user fees?
If user fees are involved, how will they be collected and from what user groups?
What are the manpower requirements for operating, maintaining, and policing the facility?
What parking restrictions will be necessary?
How will parking restrictions be enforced and who is responsible?
How will requirements for active security be handled and who is responsible?
How will unusual or heavy parking and traffic demands be handled and who is responsible?

ple, can be responsible for mis-parked vehicles that might be using more space than necessary or disrupting traffic circulation. This problem could occur because stall/aisle geometrics are too restrictive; or because of inadequate communication to the parker through signs, markings, attendants, and/or enforcement practices; or because of incorrectly located spaces or insufficient parking facility capacity.

Efficient operation of a parking facility requires a reserve capacity during peak periods to minimize redundant traffic circulation and impedance to traffic flow. Parking for most generator types should provide, in excess of the determined peak parking space demand, a 10 percent increase in curb spaces and a 15 percent increase in off-street spaces. Without these additional spaces, parkers tend to block aisles, entrances, and even access roadways while waiting for a parking space to become available. Of course, adequate reservoir space for the temporary queuing of vehicles entering or leaving a parking facility must always be provided for efficiency.

However, it is not the purpose here to discuss the numerous design and operational opportunities that must be considered to provide a parking facility. Rather, it is to emphasize that efficient design and operations are based on preliminary

planning. The better the parking needs are anticipated, the better the functional design and operational practice can be fitted to the needs to provide an efficient parking facility.

The remaining portion of this chapter briefly discusses parking space zoning regulations and building codes pertaining to parking for institutional-type generators; structured parking versus surface parking; and parking dimensions during a time of rapid change.

Zoning and Building Codes

Most local zoning regulations establish the minimum amount of parking space that must be provided at various land uses, including institutional-type traffic generators. In areas of large cities, where public transportation is widely available and private automobile use is being discouraged, zoning regulations may restrict new parking development to a maximum as well as minimum number of spaces. For example, zoning requires new hospital parking in Manhattan south of 96th Street (New York City), to provide one parking space for every 10 beds, but limits total parking capacity to 150 parking spaces regardless of whether the number of beds would dictate more spaces. [*A 1981 proposal being considered would change the zoning rule for new hospital parking to a maximum of 100 spaces with no minimum requirement. The proposal also changes the uses of permitted accessory spaces, making it more often the case that the parking must be exclusively for the use of occupants. Present law governing many types of buildings says the parking must be "primarily" for occupants' use.*]

The parking space requirements of zoning regulations are usually based on unit factors such as space-to-bed or space-to-seat ratios. These requirements are stated in generalized terms, without consideration of the site-specific needs of a particular traffic generating facility. Thus, the number of parking spaces required by zoning regulations generally do not indicate the true and practical parking space needs of the institutional-type traffic generator.

Zoning requirements can be too high or too low, depending on individual generator circumstances. Table XXI summarizes zoning requirements by institutional generator type. The diversity of zoning requirements presented in Table XXI illustrates the need for detailed studies to determine actual parking space needs. For example, the typical zoning requirement for hospital parking is 1.0 space per bed, ranging between 0.10 to 2.0. Data presented in Chapter II indicates this range to vary between 1.0 and 3.5 parking spaces per bed.

Building codes, in addition to establishing minimum physical component requirements at the facility, usually identify specific requirements for handicapped parking. Table XXII summarizes these requirements. The functional layout or design of both surface and structured parking facilities must also comply with building code provisions. These codes usually set forth minimum dimensions for parking space length and width, as well as access aisle width. The lack of specifics in stating these minimum dimensions creates some difficulties in obtaining approvals from local officials. Often, local codes do not make dimensional allowances for small cars or angle parking layouts, even though

TABLE XXI – EXISTING OFF-STREET ZONING REQUIREMENTS FOR PARKING AT INSTITUTIONAL BUILDINGS

		Museums and Libraries		Stadiums and Arenas	Colleges and Universities			Hospitals	
Requirement	Auditoriums and Theaters Spaces/Seat	Spaces/ 100 Sq. Ft. Floor Area	Spaces/ Seat	Spaces/ Seat	Spaces/ Student	Spaces/ 100 Sq. Ft. Floor Area	Spaces/ Employee	Spaces/ Bed	Spaces/ 100 Sq. Ft. Floor Area
Minimum	0.06	0.10	0.06	0.05	0.10	0.12	0.33	0.10	0.05
Maximum	0.33	3.33	0.25	0.33	0.75	1.00	1.00	2.00	2.00
Modal	0.25	0.33	0.10	0.25	0.10	1.00	1.00	1.00	1.10
Mean	0.20	0.42	0.13	0.20	0.26	0.54	0.59	0.69	0.28
Number of cities:									
With Above Basis	129	69	15	91	16	9	9	96	21
With Other Basis	57	36		53		78		70	
With No Requirement	21	87		63		82		20	

Source: Zoning, Parking and Traffic, prepared by the Eno Foundation, 1971.

TABLE XXII – TYPICAL BUILDING CODE REQUIREMENTS
Handicapped Parking Spaces

Total Spaces	Required Number of Reserved Spaces
up to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1,00	2% of Total
Over 1,000	10 plus 1 for each 100 over 1,000

Source: Standard Building Code Section 508.

functional layouts involving these aspects have become common place.

Parking facility expansion may conflict with another provision of local regulations. Many localities have established maximum development levels to reserve land as open areas or green space. Minimum green space area will vary, based on location, but can range from the absence of a requirement to as much as 30 percent of a land parcel. Minimum green space requirements may make it necessary to consider structured parking. Parking structures, however, must comply with maximum building height restrictions.

Structured Versus Surface Parking

If the decision between a structured and a surface parking facility was based solely on costs, the choice would be easier. Structured parking costs considerably more to build and to operate than surface parking. The decision, however, is usually based on other criteria, as well as costs. Often, the area of land needed to efficiently provide adequate parking is not available, or is cost-prohibitive.

In many instances, land parcels of suitable size and shape are planned for future non-parking development, making surface parking the only viable alternative for the short-term use of the site. Combination facilities, where structured parking levels are incorporated above or below other building levels designed for non-parking use, can be a cost-effective solution under some circumstances. Typical cost ranges for surface versus structured parking in 1981 dollars are given in Chapters II and III.

Environmental Considerations

Parking facility planning should include consideration of environmental impacts of such a development. Depending on circumstances, proposed facility size, location, and configuration, and state and local regulations, an assessment may be required before the project can be approved for construction. Primary emphasis for environmental impact analysis of new parking originates from concerns over obtaining acceptable air quality levels in urban areas. However, energy conservation may also become an important consideration.

Air Quality. Air pollution originating from vehicle exhaust emissions and the effect on overall air quality is the primary environmental concern in parking development. As a result of 1970 Clean Air Act legislation the federal government, through the auspices of the Environmental Protection Agency (EPA), attempted to impose parking controls that would have involved complex air quality analyses for proposed parking projects. Congress, however, never finalized or implemented action, and passage of the Clean Air Act Amendments in 1977 voided EPA proposed parking management plans and indirect source regulations related to off-street parking. This left the states faced with a choice between land use restrictions or indirect source regulation. To date, the states are responsible for establishing and policing their own indirect source regulations.

Current state regulations require project approval in regard to air quality impacts prior to construction of new parking and transportation facilities. Minimum project size for which the regulations apply, and the degree of analysis required, varies from state to state. All states can refuse construction permits if the project would adversely affect ambient air quality as perscribed by their standards.

Some major U.S. cities such as Los Angeles, Chicago, New York, and Boston have established air quality regulations that restrict certain existing parking and require prior approval of proposed parking projects. A few cities have placed strict limitations on new parking development, primarily in the central business districts, to discourage private vehicle use in order to attain several objec-

tives, including reduced downtown pollution. Imposed parking bans, however, have been fraught with political controversy and have not been widely used.

An efficient parking facility reduces adverse impacts on air quality by:

1. minimizing the queuing time of idling vehicles waiting to enter or leave the facility;
2. providing vehicular circulation that does not cause vehicles to block or impair access along adjacent streets; and by
3. reducing redundant traffic circulation within and outside of the parking system to cut vehicular running time and travel distance.

Energy Conservation. Proper placement and design of parking facilities can save many gallons of motor fuel per year. The general location of a proposed parking facility is fixed by its requirement to serve a particular traffic generator. The only options may be how the parking facility is oriented on the site and/or a possible choice between more than one available site that could adequately serve anticipated parking needs.

In actuality, there are no real incentives to select the most efficient parking site or development orientation in regard to energy conservation alone. Many factors particularly costs, are typically given more importance than energy conservation. Fuel efficient parking design and operation, however, are frequently byproducts of other concerns to optimize efficiency in a parking project. For instance, the same location, design and operational features that contribute to minimizing air pollution (reduced idling time and travel distance) also act to conserve motor fuel.

Other Environmental Concerns. While not considered serious enough to warrant special regulatory programs, potential noise and water runoff problems should be recognized in the planning of a parking development. Educational, health care, and certain cultural activities can be particularly sensitive to noise and vibration. If a problem potential is anticipated, practical opportunities to separate or shield the noise/vibration source from critical activity areas should be implemented. Storm drainage, snow removal and melt-down storage should always be adequately provided for in an acceptable manner.

Depending on location, headlight glare and spillover lighting could present an objectionable situation to neighboring development. Potential problem areas should be anticipated, and adequate provisions made to screen or concentrate light sources to prevent or minimize problems.

Mitigating potential adverse impacts on the environment during construction should be anticipated. Measures that could be necessary include modification of working hours, traffic detours and special handling, or special materials handling requirements to protect the environment. These measures, as well as others, affect costs and project feasibility, and should be recognized in the planning stage of off-street parking facilities.

Parking Dimension Variations

Efficient use of space calls for balancing generous dimensions for parker convenience with restrictive dimensions for maximum economy. For institutional and special event parking, the appropriate parking dimensions should be based on vehicle size and operating characteristics, and parker characteristics.

Since the mid-1970s there has been a trend in the United States toward the production and use of smaller cars. The reasons behind this are basically increased fuel economy and lower operating costs; factors that have been catapulted to the top of most motorists' list of concerns due to a number of widely expounded reasons. The reduced overall length and width of most newer automobiles offers some opportunity to increase parking facility space-use efficiency, since smaller cars require less area on which to park than the older, larger automobiles. However, the older, larger cars continue to represent a significant portion of vehicles stored in parking facilities. Generally, parking layouts must be designed to accommodate the largest vehicles expected to use the facility.

Parker characteristics influence stall and other parking dimensions. Conditions of high parking turnover and/or where parkers may be unfamiliar with the facility, may call for more generous stall dimensions than minimum requirements. All-day or long-term (low turnover) employee parking may justify dimensions closer to minimum requirements.

Dimensional Elements of Parking Layouts. The parking bay is a fundamental element referring to the combined distance of aisle width and stall

depth, measured perpendicular to the access aisle. Parking bays may be composed of one- or two-way traffic aisles, with parking stalls on one or both sides. Aisles having parking stalls on both sides are defined as double-loaded aisles, and with stalls on one side only as single-loaded aisles. Single-loaded aisles are less efficient and generally avoided where possible.

The ease in which a vehicle can turn into a stall is influenced by stall width, parking angle and driving aisle width. These factors are ultimately a function of the parking bay dimension, which typically ranges between 54' and 63' in width for double-loaded aisles.

For self-park facilities, parking stall widths typically range between 8'-4" and 9'-0" depending upon the angle of parking. The average dimensions of a large car parking stall are 8'-6" to 9'-0" × 18'-0", however, more generous dimensions are typically used in high turnover facilities, and are frequently required by local zoning. Experimentation has shown the most advantageous small car stall dimensions to range between 7'-6" to 8'-0" in width and 15'-0" to 16'-6" in length. European parking stalls, which have always catered to the smaller car, are typically 8'-0" × 16'-0".

High volume short-term parking activity, where 5 to 15 stall turnovers per day are experienced, requires a generous stall width dimension to accommodate the greater frequency of vehicle door openings and parking manuevers. Under this condition, an 8'-8" stall width can adequately park the standard size (large) automobile, given enough bay width for the parking angle used. Lower volume parking activity having 3 to 5 turnovers per stall per day may be able to use somewhat smaller stall widths. Stalls for long-term parking may use 8'-6" widths if parking bay widths are adequately sized for the parking angle.

Typically, two-way aisles are used with 90-degree parking, and one-way aisles are used with angle parking. Aisle systems should function to minimize turns. Longer aisles can be advantageous in this respect, but may require one or more cross-over aisles for dispersion of parking activity and assurance of minimum travel.

Generally, the aisle width is determined by the maneuvering space required to move a vehicle into and out of the stall. As the parking angle used becomes flatter, a point is reached where required manuevering room is less than acceptable driveway width. Aisle width can be measured between the furthest projection of stall markings, however, it is more logical to base the aisle width on the distance between parked cars rather than the distance between painted stalls. This is particularly true for very flat parking angles (45-degrees and less). As a convenience to the planner it is usually simpler to specify a parking bay width rather than an aisle width. The minimum desirable distance between parked vehicles for a one-way traffic aisle is 12 feet. For two-way traffic aisles, the minimum aisle width is 20 feet between vehicle projections. Longer dimensions of up to 15 feet (one-way) and 24 feet (two-way) are recommended for more efficient internal circulation.

Table XXIII suggests ranges in parking bay widths

TABLE XXIII – RANGES IN PARKING BAY WIDTHS FOR DIFFERENT STALL LAYOUTS

Parking Angle (θ)	Stall Width (S_w)	Minimum[b] Parking Bay Width (W_2)	Desirable[c] Parking Bay Width (W_2)
90-degree (Two-way Traffic)	9'-0"	60'-0"	61'-4"
	8'-8"	61'-4"	62'-8"
	8'-4"	62'-8"	64'-0"
	7'-6"[a]	54'-0"	54'-0"
75-degree (One-way Traffic)	9'-0"	57'-7"	58'-8"
	8'-8"	58'-8"	59'-8"
	8'-4"	59'-8"	60'-11"
	7'-6"[a]	51'-10"	51'-10"
60-degree (One-way Traffic)	9'-0"	53'-7"	54'-6"
	8'-8"	54'-6"	55'-5"
	8'-4"	55'-5"	56'-6"
	7'-6"[a]	48'-5"	48'-5"
45-degree (One-way Traffic)	8'-8"	48'-6"	49'-4"
	8'-4"	49'-4"	50'-3"
	8'-0"	48'-5"	48'-5"
	7'-6"[a]	44'-2"	44'-2"

[a] For small cars only.

[b] Long-term, low turnover parking.

[c] Short-term, frequent turnover parking, including most special event parking.

Note: See Figure 20 for dimensional identification. These dimensions are based on self-park operation, and except for the 7'-6" small car stall, assume an 18'-0" stall length. Parking bay widths are for double loaded aisles.

Source: Adapted from *Parking Standards Study* (1979), Parking Standards Design Associates; and *Parking Design for Small Cars* (1974), Richard F. Roti.

for different stall dimensions and parking angle combinations. Parking layout efficiency depends on selection of stall and parking bay dimensions that will provide a desired degree of service and economy while using a given site to its best advantage. The objective should be to maximize the number of vehicles that can be parked within a given area, subject to predetermined operational constraints. Ninety-degree parking stalls with aisles parallel to the long dimensions of the site, and 60-degree interlocking parking stalls with one-way aisles, usually require the least amount of space per stall.

Angled parking stalls may provide greater ease in parking than 90-degree stalls, and may derive some advantage in the fact that drivers are able to see and anticipate empty parking stalls more easily. Angle parking is often used where site dimensions will not allow sufficient parking bay width for 90-degree stalls. If adequate aisle width is provided, 90-degree stalls can be as convenient and safe as angle parking. At parking angles of less than 90-degrees, access aisles are normally one-way. Sometimes this is desirable; but one-way aisle systems may also cause drivers to travel further within the parking facility, increasing circulation time and the opportunity for conflict with pedestrians and other vehicles. The two-way aisles of a 90-degree parking layout provide room to pass a standing or waiting vehicle. Other advantages of a two-way aisle system include better sight distance at aisle intersections and fewer aisles, hence shorter travel distance to locate an available parking space.

Accommodating the Small Car

The passenger automobile population in the United States is comprised of 55 percent large cars and 45 percent small cars. However, with specific areas and generators, the vehicle size mix can vary dramatically from the 1980 national average. Some researchers predict by as early as 1985, small cars will represent 75 percent of the automobile population.

From most estimates, it appears that the automobile population will continue to increase but with a mix of predominantly small cars, approaching characteristics of the European auto population that is almost exclusively composed of small cars. Exceptions to this trend can occur in locales where there is heavy use of light trucks and/or recreational vehicles for personal transportation. Currently, the vehicle size mixture can vary greatly between different types of generators, different communities, and different regions. There have been no comprehensive studies that indicate conclusively that parkers generated by medical or educational institutions drive small automobiles in greater proportions that other segments of the driving public. However, many in the parking industry tend to believe that work-trip commuters generally drive smaller cars.

Alternative Approaches. Experience has shown local surveys provide the most reliable base for an assessment of small car usage. Continued demand for small cars may tend to equalize small car distributions between various locales and sections of the country. This emphasizes the importance of the local survey to determine automobile size distribution and as a basis on which to justify requests for zoning variances concerning the size of stall that must be provided.

In order to take advantage of the reduced parking area requirement for the smaller car, several approaches are available to the designer/developer.

1. The parking facility can be designed to provide a parking module that will park the larger cars in the existing vehicle population at an angle of 60 to 65 degrees. This layout will facilitate conversion to 75 to 90 degree (using smaller parking stalls) small car parking in the future.
2. A new parking facility can be planned to incorporate two different sizes of parking stalls catering respectively to large and small cars. (Some communities have zoning regulations that specify the maximum amount of small car stalls that can be provided.)
3. Or, the entire facility can be built with slightly reduced standards using only one stall size.

Alternative #1 could be appropriate in situations where a fairly high proportion of full-size (large) cars must be accommodated today. In situations where it is known that the parking clientele will have a predominant number of small cars, consideration could be given to using two different size parking stalls as proposed in Alternative #2. Where a high proportion of the users will be commuting employees who tend to drive a higher proportion

of small cars and exhibit low parking turnover characteristics, providing up to half of the facility's parking capacity in small car stalls could be feasible. In comparison, facilities intended to serve high parking turnover should incorporate a lesser percent of small car stalls, if any at all. In all situations, the proportion of small car stalls that could be provided depends on the anticipated mix of small and large cars in the vehicle population as determined by available information for a particular site and generator type.

Until small cars in use reach 70 to 75 percent of the total vehicle population, it will be most prudent to provide a lesser number of small car stalls than a survey might indicate as being possible. Again, this is particularly important when planning to use small car stalls in short-term, high-turnover parking situations.

As an alternative to a double standard for parking stall geometrics, one uniform, slightly smaller stall width could be used throughout a parking facility, as suggested in Alternative #3. The appropriate stall size should be determined on the basis of the type of parker—long- or short-term—and other parking characteristics, as well as the degree of convenience to be provided to the parker. The New York and New Jersey Port Authority, for example, now uses an 8' 4" stall width throughout their parking systems. Even though this stall width is rather tight for the largest cars still found in the vehicle mix, the Port Authority's experience suggests that it is rare when two large cars are parked adjacent to each other and not separated by a small car. Thus there is usually adequate door-opening room for the large cars parked in the spaces.

Special Operational Controls. If special size parking stalls are used in conjunction with standard size stalls, the critical factor is to obtain full use of the two different stall types by vehicles of the size classification for which the stalls were designed. Two approaches to optimizing usage are possible.

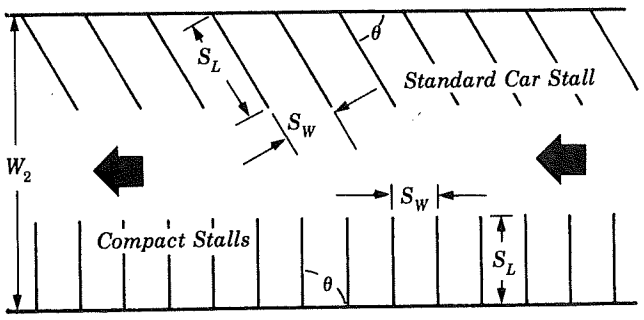
1. Physically separate the small car stalls from parking areas containing large car stalls using lower parking fees and/or signing to attract small car use.
2. Integrate small car stalls within the same general parking area provided for large cars, and depend on signing and restrictive geometrics to control voluntary use.

The first approach is difficult to control and discouraged for the general public's use by at least two factors. First, a more complex set of parking rates would be necessary and the increments between the rates would probably be small. Secondly, fragmented parking areas would foster operating problems of revenue security and of diversion from filled lot sections. For institutional facilities, however, these objections can often be overcome, since institutions can be more dictatorial in directing staff, employees, and students in where to park. Also the collection of user fees may not present a problem.

The second approach is more widely used, but requires several key features to help ensure effective use of both small and large car stalls. The proper use of the small car stalls should be self-enforcing to avoid added operating costs and misuse that detracts from capacity gains or patron service. Small car stalls should be marked differently from large car stalls. A minimum of one foot in width is suggested; that is if a large car stall is 8.5' wide, then the small car stall should be 7.5' in width. Studies have shown a substantially lower frequency of large cars in small car violations with 7.5' wide small car stalls than with 8.0' stalls for small cars. Also, the two different size stalls should be marked differently: for example, white stall markings for large car stalls and yellow for small car stalls. Prominently posted signs and/or pavement markings are also necessary. Stall end lines, painted parallel to the aisle and connecting the two side lines of a small car stall are helpful in discouraging drivers of large cars from using the smaller parking stalls.

Some parking facility operators have found that placing small car stalls in the most conveniently accessible areas of a parking facility assures that they fill and are totally utilized before small cars must begin parking in the larger stalls. However, this may also encourage large cars to attempt using the smaller spaces. Making both small and large car stalls equally convenient (in terms of walking distance) is still another approach, but difficult to effect. Small car stalls should be located and sized (in terms of total parking capacity) so that they always fill before the entire parking facility. Otherwise, large cars will be forced to use small car stalls.

Figure 20 illustrates one method of providing a self-enforcing mix of stall sizes. It employs large car



Module Width (W_2)	Parking Angle (θ)	Compact Car Stall Width (S_W)	Standard Car Stall Width (S_W)	Stall Length (S_L)
54	60		9.0	18.0
54	90	7.5		15.0
50	60		9.0	18.0
50	90	7.5		15.0
48	45		9.0	18.0
48	90	7.5		15.0

Figure 20. One method of providing a self-enforcing mix of stall sizes

parking stalls at 45 to 60 degrees on one side of an aisle and 90 degree compact or small car stalls on the opposite side, with a module width of 55 feet. Large vehicles cannot turn into the 90 degree small car stalls without backing at least once to complete the parking maneuver. Thus, fewer large cars can find the small 90 degree stalls convenient. With one-way aisles necessary to this system, there is a possibility of drivers unparking from the 90 degree stalls and inadvertently leaving in the direction opposite to the intended traffic movement. The flexibility of this design allows the initial parking layout to park today's mix of car sizes, yet permits economical and efficient conversion to small stalls in the future, if justified.

Second Thoughts. When contemplating parking facilities designed to store and process small cars, it is wise to keep the opportunities as well as the potential problems in focus.

The streets, highways, and other automobile accommodating facilities in the United States are already sized for the large car. American car sizes have typically experienced constant change since the automobile was first introduced. The automotive industry is making rapid technological advances in the production and use of light-weight automotive structural members, more efficient multiple-fuel power trains, and improved aerodynamics – advances that could enable large cars to be extremely fuel efficient in the near future.

The American car buying public has demonstrated they are more interested in fuel economy than smaller size, and historically, they have preferred larger cars to smaller cars. It may not be unreasonable to project that once Americans become accustomed to higher fuel prices, and large cars become more efficient, demand may again be for large 6-passenger cars.

Conclusion

Rising development and operating costs make it increasingly difficult for off-street parking that serves institutions and special events to be financed from user revenues alone. Consequently, off-street parking is viewed as an essential service in which the institution or special event activity must offset a portion or all of the costs.

Each institution must identify the type of parking program best suited to its particular needs and resources. The individual institution assumes the primary responsibility in program formulation and administration. Parking should be viewed as part of a total transportation system relating to pedestrian circulation and public or shared-ride transit opportunities, as well as the processing and storage of private automobiles.

Changing technology and economic conditions have brought about significant changes in parking design and operation, and new approaches to parking facility development and financing. The planning, location, design, and operation of off-street parking involves balancing economic, engineering, environmental, and use considerations. Thus, it will behoove an institution to seek experienced professional help in these areas to ensure optimum use of available resources for an economical and efficient parking program. Once in place, the parking operation should be kept current through a system of regular review and financial monitoring to enable it to adapt to changing requirements and policies, while maintaining economy and efficiency.

APPENDIX A

TABLE A-I – CHARACTERISTICS OF STUDY GENERAL HOSPITALS

Study General Hospital	Hospital Location	Beds	Daily Employee/Staff Population	Daily Visitor/Outpatient Population	Percent Auto Drivers			Peak-Period Accumulation of Parked Vehicles	
					Employee/ Staff	Visitor/ Outpatient	All Trips	Time[a]	Number
A	Trenton, NJ	381	833	1,210	91	79	–	10:00 A.M.	800
B	Winchester, VA	443	1,082	580	73	–	–	3:00 P.M.	611
C	Dallas, TX	680	2,126	1,542	60	67	63	10:00 A.M.	1,074
D	Los Angeles, CA	400	1,016	1,389	58	75	60	3:00 P.M.	766
E	Cumberland, MD	274	1,030	1,315	80	57	67	3:00 P.M.	554
F	Bridgeport, CT	652	–	–	77	55	63	10:00 A.M.	560
G	Buffalo, NY	420	1,410	987	67	81	73	3:00 P.M.	850
H	Philadelphia, PA	469	1,000	4,460	83	48	54	11:00 A.M.	1,100
I	Norristown, PA	214	750	1,150	87	68	75	3:00 P.M.	535
J	Boston, MA	311	1,026	650	–	–	78	3:00 P.M.	802
K	Los Anglese, CA	325	1,580	1,020	67	55	59	3:00 P.M.	884
L	Burlington, MA	200	1,240	4,079	73	71	71	10:00 A.M.	565
M	Miami, FLA	510	2,400	3,530	70	25	48	3:00 P.M.	1,010
N	Lynchburg, VA	313	865	985	90	77	83	10:00 A.M.	527
O	Manchester, CT	303	700	1,000	85	80	–	3:00 P.M.	600

[a] Hour of day during which the peak accumulation of parked vehicles occurred.

TABLE A-II – CHARACTERISTICS OF STUDY MEDICAL CENTERS, SPECIALTY HOSPITALS AND EXTENDED CARE FACILITIES

Medical Center Location		Beds	Daily Employee/ Staff Population	Daily Visitor/ Outpatient Population	Percent Auto Drivers			Peak-Period Accumulation of Parked Vehicles	
					Employee/ Staff	Visitor/ Outpatient	All Trips	Time[a]	Number
Study Medical Centers									
A	Dallas, TX	800	1,900	–	67	–	–	2:00 P.M.	1,990
B	Farmington, CT	210	3,354	600	91	83	89	11:00 A.M.	1,950
C	Bridgeport, CT	391	1,905	1,387	–	–	53	10:00 A.M.	870
D	Hartford, CT	700	2,825	2,405	87	83	85	3:00 P.M.	1,575
E	Detroit, MI	1,760	10,550	6,925	75	51	67	3:00 P.M.	6,920
F	Richmond, VA	1,000	8,400	2,555	58	42	58	11:00 A.M.	3,460
G	Pittsburgh, PA	1,389	8,000	–	55	44	48	11:00 A.M.	2,315
H	Philadelphia, PA	859	3,345	6,010	67	50	59	3:00 P.M.	1,645
I	Long Island, NY	532	2,362	3,190	81	67	59	2:00 P.M.	1,665
J	Winston-Salem, NC	479	2,062	1,830	63	–	–	2:00 P.M.	1,200
K	Trenton, NJ	380	835	1,210	91	66	–	3:00 P.M.	1,075
L	Pittsburgh, PA	438	1,650	2,960	45	49	–	1:00 P.M.	960
M	Newark, NJ	554	1,950	3,070	52	63	–	3:00 P.M.	1,300
N	Queens, NY	693	3,055	4,035	81	66	–	3:00 P.M.	2,170
O	Philadelphia, PA	619	2,690	2,190	67	50	–	3:00 P.M.	1,435
Specialty Hospitals									
A	Pittsburgh, PA	225	1,330	3,600	49	25	–	11:00 A.M.	1,558
B	Buffalo, NY	320	1,290	–	75	51		3:00 P.M.	790
C	Pittsburgh, PA	175	700	2,200	50	52	–	12:00 Noon	650
Extended Care Facilities									
A	Philadelphia, PA	102	145	45	65	60	59	3:00 P.M.	75
B	Philadelphia, PA	138	490	345	67	50	–	3:00 P.M.	250
C	Long Island, NY	203	695	845	81	67	–	3:00 P.M.	505

[a] Hour of day during which the peak accumulation of parked vehicles occurred.

TABLE A-III – UNIVERSITY STUDY CHARACTERISTICS

Study Institution	Location of Study Institution	Population at Time of Study[a]	
		Students	Faculty/Staff
A	California	21,500	995
B	California	22,600	960
C	Connecticut	18,800	4,600
D	Virginia	6,800	2,150
E	Pennsylvania	24,200	7,380
F	Texas	23,700	2,685
G	Texas	18,700	2,900
H	Kentucky	10,200	765
I	Missouri	9,700	740
J	Oregon	8,800	–
K	New York	10,600	–
L	New Jersey	8,500	2,100
M	South Carolina	5,000	–
N	Massachusetts	26,000	2,650
O	Washington	19,700	7,430
P	Michigan	5,000	–

[a] Studies conducted between 1969 and 1979.

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