

A SYSTEMS APPROACH TO THE STUDY OF THE TRANSPORTATION
FACILITIES SERVING KSU STADIUM

by 45

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INTRODUCTION

In this world of modern technology there seems to be at least one characteristic trait of all urban scenes. This typical trait is the difficulty involved in developing and maintaining the transportation system. This is not a problem that is new in the world; 2,000 years ago the city of Rome found it necessary to restrict vehicular traffic, except for war chariots and state vehicles, to the night hours.

The transportation problems of the modern American cities are largely the result of the attitudes of the people themselves. The problems are brought about by people taking advantage of individual opportunities. Individual opportunities and their effect on transportation take on many forms. People are free, because of their wealth and mobility, to choose the place they want to live. This has increasingly resulted in the sprawl of the cities and the sprawl of the city and daily rush to the city for work accounts for a large part of the urban traffic problem.

Another form of individual opportunity is the role of leisure. Leisure is an important part of this country's social system. Philosophers have gone so far as to say that leisure is the basis of all of western culture. How does leisure apply to the urban transportation scene? The answer is that it is the manner by which this leisure is spent that

affects the urban transportation scene. Increasingly we find events of entertainment that result in a crush on the transportation system. At work are generators that can, on special occasions, attract the equivalent of one out of every thirty people in a community of 3,000,000. These generators can attract 35,000 people to a single location in a city of 25,000.

It is not an accident that these special events and their resulting overwhelming demands on the transportation system are steadily increasing. As society has become more affluent and mobile, special events or attractions have developed a larger base of appeal.

What is a special event? A special event can take many forms; it can be a political rally, a religious gathering, or purely entertainment. What characterizes the gatherings is that they are infrequent in nature. This infrequency, plus the broad base of appeal from which it draws, creates massive gatherings of people. It is not uncommon to attract 80,000 or 100,000 people to a very confined area to enjoy a concert, an athletic event, or rally. This type of event has become such an important part of America that we see facilities developed to exclusively handle these special events. A sports complex is an example of one such special facility. A point of concern is the manner by which people get to these events. Thus an integral part of the design of these special-event facilities is the manner in which the "traffic problem" should be handled.

The plight of traffic connected with special events raises many questions. How ethical is the expenditure of large amounts of public funds for transportation facilities serving areas which are used intensely but infrequently? What type of transportation should be provided? Will the public's criterion for modal choice, that is the method of transportation they choose, change from that found for, say, the work trip?

These are profound questions one must answer when dealing with the transportation facilities to handle special event demands and it is indeed unfortunate that there is so little information available. Even simple questions such as vehicular occupancy and vehicular rates of flow are not well answered.

In searching references related to this area of study one is able to piece together certain fragments of information. One of the better sources of data is a study of the Jackson County Sports Complex in Kansas City, Missouri.¹ To develop a transportation system for this complex a study of the Municipal Stadium in Kansas City was undertaken. Information on distribution of arrivals, modal split, and car occupancy was developed. It was found that 62% of the total number of vehicles arrived at their parking space within an hour period 12:05 P.M. to 1:05 P.M. The Municipal Stadium had a well developed transit system. This system had several shuttle locations at various points in the metropolitan area. Transit accounted for an average of 22.05% of the arrivals at the stadium. The range of arrivals by transit varied between 26.60% and 17.78%. Vehicle occupancy was found to be 3.53

occupants per vehicle (occ/veh). This is a high occupancy rate resulting from the pressurized facility. In this context a pressurized system is one where the crowded constrained conditions cause an occupancy and choice of mode different than would occur without the constraint of congestion.

Occupancy data are probably the only type of information that can be substituted into a study at another location, since the distribution of arrivals and modal splits are strongly subject to constraints of the locale.

The design of the Angels baseball stadium parking lot at Anaheim, California, also offers some information.² This lot design provided 11,520 spaces for the general public, 255 spaces for buses, and 225 for participants and officials. The lot is served by a total of twenty lanes of expressway. The stadium which this lot serves is capable of holding 45,000 people. The size of the lot is in accordance with the 1 to 4 ratio of parking space to seating capacity recommended for design purposes.³

Referring to the availability of material on special events traffic it can be said that the very nature of the problem precludes a set of rigid numbers defining its operational capabilities. Special event traffic tends to flood the street system surrounding the desired structure. Therefore, initially, the demand volumes are restricted by the individual system. This restriction can force a change in demand distribution, occupancy, and modal split. It can be said, then, that each special event facility is individualistic in

its characteristics. Therefore it tends to seek its own occupancy, volume, modal split, and arrival distributions.

It is the purpose of this work to examine one such sports complex, the KSU Football Stadium. This is a new football facility for Kansas State University and is designed to handle 35,000 patrons. The examination of this facility is directed toward providing a comprehensive transportation system to serve the stadium.

A secondary purpose of this work is to define and provide an example of the "systems approach" by which a design problem can be undertaken.

SYSTEMS APPROACH

To perform any task an individual must have a process, a procedure, by which his actions and thoughts are directed. This is true relative to both the simplest manual task or the most demanding intellectual endeavor.

If one would examine the actual technique he uses to solve his everyday problems and if he were able to formalize this technique, insight into what is termed the "systems approach" would be gained.

John Dewey, a well known philosopher and educator of the 19th and early 20th century, did much to clarify the problem-solving process. "To put it roughly in Dewey's words, an individual who has a problem finds himself in an indeterminate situation. He starts an inquiry when he begins to interact with his environment. Then he tries to define the problem. When this is done, he gets ideas that may solve the problem. Finally he evaluates the ideas to see how good they are for solving the problem."⁴

Diagram of the problem solving process
(Figure 1)

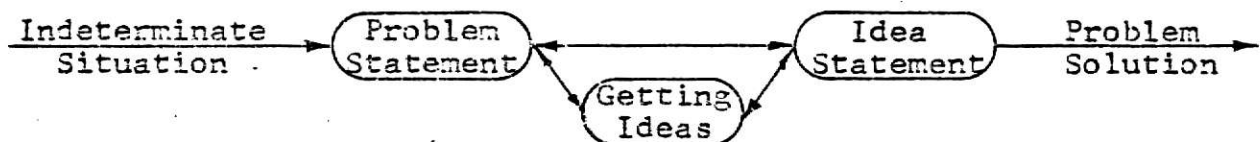


Figure 1 is a schematic representation of Dewey's statement of the problem solving process. The double arrows in this figure indicate two items of importance. First, they show that each of the three areas is of equal importance and second, each of the areas can be the origin of the cycle. The workability of the diagram is readily apparent when entered in the problem-statement phase. It is equally valid, however, if entered at the idea phase. For instance, everyone has had ideas and in determining whether these ideas could be implemented various problem areas were uncovered. It is then necessary to evaluate the idea to see if it is feasible in view of these problems. Likely, the original idea had to be modified slightly to handle the initial problems that were uncovered. The new idea then would be evaluated and hopefully the initial problems would have been solved and no new problems created.

This process is a small scale form of what is known as the "systems approach." Much has been written lately on this subject.^{4,5,6,7} This influx of material would lead one to believe that this is a new subject. As has just been demonstrated, however, this is not the case. What is new is that writers in this field have become aware of the need to formalize an approach. Literature on the systems approach is somewhat vague and is often tinted by the author's intra-discipline language. When one is able to overcome the initial confusion due to the language it becomes apparent that the authors are, in fact, saying the same thing. Their message

is that the systems approach is a process; a process that differs from one engineering field to another not so much because of its approach but more because of the constraints under which it operates.

In order to proceed further in this investigation of the systems approach a vocabulary must be developed. It can be said that a system is a "set of objects with relationships between their properties."⁴ Every system is composed of parts, or subsystems, and is at the same time a part of a larger system. The human body serves as a good example to illustrate this point. If one considers a human as a system we are quite aware that this particular system is a part of a larger system, his environment. The human in turn can be thought of in terms of subsystems of which he is composed. The nervous system and circulation system are examples of such human subsystems.

"For a given system the environment is the set of all objects outside the system: (1) a change in whose attributes affect the system and (2) whose attributes are changed by the behavior of the system."⁴ In terms of traffic engineering and transportation engineering the environment as defined above can be seen as the roadway, transportation network, community, state, or the nation in general depending on the scope of the project under study.

Since transportation deals with people and their aims, a broader discussion of its environment entails classification into four areas:

- (a) physical environment
- (b) economic environment
- (c) social environment
- (d) political environment

A transportation system is termed an open system. That is, the system and its environment interact. The four areas listed above are broad classifications of the type of environmental elements that are found in a transportation system.

Possibly the most important aspect of the system approach is its feedback ability. Feedback is the returning of a fraction of the output from the analysis of one subsystem to the input of another subsystem. This action has the effect of relating and integrating various indeterminate situations into a unified whole.

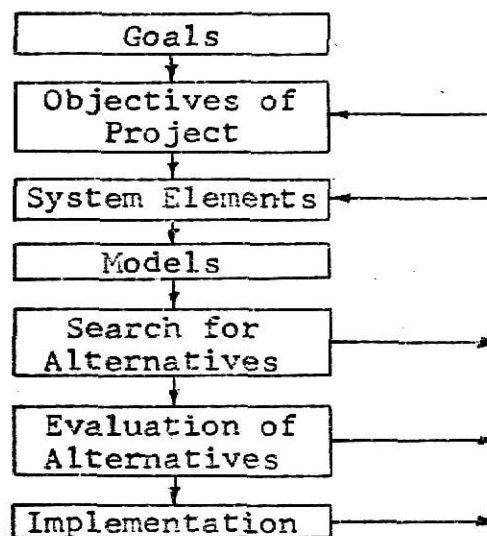
The systems approach itself in relation to transportation is "fundamentally a decision-making process. It considers alternative approaches to overall design (or to a problem) to arrive at a system that provides optimum performance with respect to established criteria. The system itself may be an integrated assembly of interacting elements, components, or subsystems, designed to carry out collectively a predetermined function. The systems approach is best suited to dynamic problems, where conditions of load, capacity, environment, or other information inputs vary with time."⁵

The systems approach does not in itself guarantee that the resulting design is going to have more sophistication. It is hoped that the systems approach will "ensure that all

relevant variables, conditions, and aspects are considered, and consistent designs obtained."⁶

The following is a definitive approach to the system concept. The definitive approach is given here to indicate the steps involved in the systems process.

Steps in the systems process
(Figure 2)



Goals and Objectives

Clarity between the first two steps in fig. 2 entails the definition of the words, goals and objectives. Goals, as described by most authors in the field, are general long-range aims that should serve as an asymptote of planning. Objectives on the other hand are the calculated end results of particular programs directed toward reaching goals that have been established by the appropriate decision makers.

The biggest obstacle in regard to the relationship between objectives and goals is that there is great uncertainty

connected with the evaluation of immediate objectives in relation to the ultimate goal. How are the objectives achieved by various alternatives or projects rated in reference to the goal to which they are aimed?

System Elements (Subsystems):

The next step in the systems process is to measure subsystem elements or variables that affect the project. This is a major point of interest. For the traffic and transportation engineer, these elements certainly contain origin-destination studies, volume counts, etc. and involve such areas of concern as:

- "1. Economic factors affecting development. (These include natural resources, climate, land structure, physiographic location relating to trade routes and resources. Included also are traditions of regional development policy, political organization and controls, customs and social structure.)
2. Population
3. Land use
4. Transportation facilities
5. Travel patterns
6. Terminal and transfer facilities
7. Traffic control features
8. Zoning ordinances and building regulations
9. Financial resources
10. Social and community values"

Models

Formulation of project models is the next step that should be undertaken. The three types of models available to the designer are: (1) physical model, (2) analog model, and (3) symbolic model. The fact that none of the three types of models mentioned above is fully capable of handling the social

implications involved in the design it represents is unfortunate.

Physical models are nothing more than scale representations of the project. Their principal failing is that they are lifeless. Physical models of lifeless projects such as hull and fuselage designs are very successful in providing information to the designer. In the transportation area they serve only the lifeless phase of design of planning.

"Analog models do not assume the appearance of the project being modeled but behave or function in a similar fashion."⁶ In traffic we have applications of liquid and electrical flow concepts to the vehicular traffic flow. These representations again lack life and true realism. Humanistic effects such as psychological implications of congestion are lacking. How does one measure the psychological effect of the water molecules or electrons within the congested pipe or wire? What is the effect of a pipe or wire on the pool of water or ionized field in which it exists?

The symbolic model offers the best hope of providing an unbiased, realistic approach to design and accurate modeling. Drew's⁷ application of statistical distributions to basic driver operations and the corresponding use of these distributions in the design and modeling process represents a very noteworthy attempt toward achieving the needed social implication in design.

Generation of Alternatives

The next step is the search for and specification of alternative designs. A great deal of work has been done in this area. Some of this work is directed at "formalizing the route-location problem so that specified locations can be analyzed more quickly, cheaply, and accurately, but it is presently restricted to consideration of construction, right-of-way and user costs."⁶

In the future it could well be that social criteria can be similarly formulized. Already much work is being done in the area of computer drawn perspective interpretation of proposed highways.⁸ These perspective drawings have a definite application in pointing out both potential hazards and aesthetic considerations.

Evaluation of Alternatives

The next step indicated in fig. 2 is the evaluation of project designs. This step reflects many of the important aspects of the process. For instance if the best alternative were not even considered, it is equally doubtful that it would be selected. If modeling techniques were employed that were not applicable to the real life situation the best alternative would in all likelihood not have been selected. If improper or insufficient project elements have been determined again there is little chance of selecting the best design. The objective of the project is what is really being tested. For it is the feedback loops between the various steps in the process (as indicated by arrows in fig. 2) that create good design.

If we have a certain project to be undertaken and with it certain objectives to accomplish, it is possible that we have developed the best set of alternatives to implement this objective. But the objective so implemented may not contribute sufficiently to the attainment of the ultimate goal to warrant its implementation. In this case the objective must be re-defined and the design process repeated because it was initially undertaken with an incorrect objective.

Implementation:

Implementation and operation of the preferred alternative is a very important portion of the design process. The main concern is with the type and degree of implementation of the project proposed. The partial system that is implemented might possibly work to the detriment of the objective for which it is constructed. If it is found after the selection of the best alternative that the implementation is of such a nature as to adversely affect the objective for which it strives then the design process must be re-entered at one of three stages. Possibly the "objective of the project" must be altered or new or different "system elements" must be measured. The implementation might call for nothing more than different "modeling" of the project and the resultant operation. The important consideration is that the project alternative is affected by time. One cannot accept, without having considered its effect, the partial implementation of the delayed implementation of the project.

APPLICATION OF PROCESS TO KSU STADIUM TRAFFIC STUDY

The preceding section was an introduction to the process by which the traffic study at the new Kansas State Football Stadium was undertaken.

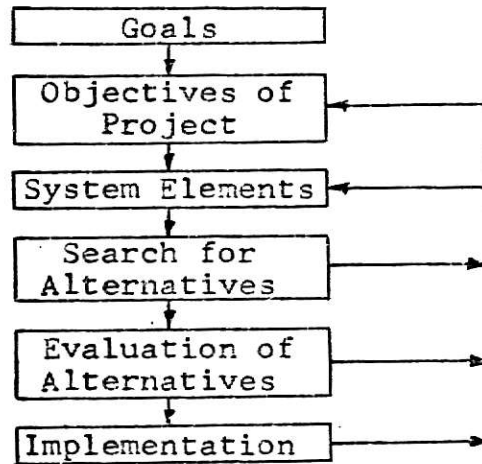
As mentioned earlier the systems approach is applicable to any problem solution. The traffic study at KSU Stadium was no exception. As is characteristic of the systems approach the study of traffic at the stadium generated several important subsystems. In order for the stadium's transportation system to work these subsystems had to be integrated into a workable unit.

It must be stated that the process outlined earlier was not followed completely in this study. Because of a lack of information the fourth step in the process, models, was omitted. The important aspects of the modeling step that were necessary for the development of the study were included in the search for alternatives step. The process that was used is shown in fig. 3.

Goal and Objective of Project

The inquiry was then initiated with what Dewey⁹ would have called an indeterminate situation. Certain constraints and limitations surrounding the stadium seemed to suggest that a problem was apparent. A specific problem was not defined.

Process used in KSU Stadium Study
(Figure 3)



What was known was the goal of the stadium and the objective of the study. A general goal of the facility was to make the games as entertaining as possible. The objective of the study was to provide appropriate parking and transportation facilities. Some explanation of this objective is needed at this point. The key word in the statement of the objective is "appropriate." What is appropriate? It was felt for this study that the new stadium should not place unnecessary hardships on its patrons. That is, it should not make people accept transportation methods inferior to those available at the old stadium.

By defining the goal and objective the first two steps in the systems process were negotiated. The stage of the process is shown schematically in fig. 4.

same time the feedback concept was utilized. First however, it was necessary to initiate a preliminary inquiry to establish interaction between subsystems.

The first subsystem that was studied was the surface streets. The inquiry into this subsystem was undertaken first because this was a permanent physical system. This system had to be accommodated because time and finances were not available to measurably change this system.

The new stadium was fronted on two sides by roadways. . All traffic destined for the stadium therefore had to eventually travel these streets. In the immediate stadium area both these streets had two twelve-foot lanes with two stabilized ten-foot shoulders. During peak demand it was possible for them to handle four lanes of traffic. The fronting roadways were fed by five city streets each with two twelve-foot lanes. The major difficulty with the surface street system was that only two of the feeder streets were oriented in the desired direction of travel for the majority of patrons. Another disadvantage was that two other feeder streets were essentially serviced by one two-lane facility.

An inquiry into the modal split took on several phases. First, what modal split was likely to occur naturally? Would this modal split work with the expanded attendance and low surface street capacity? What measures should be undertaken in view of the answers to these two questions? The second inquiry concerned the acceptability of the various modes available to the public.

The lot design, having preceded this study was considered a subsystem. Several facets of this design had to be incorporated into the overall system. Some of the important features to consider were: (1) number of vehicles per lot, (2) entrance dimensions and location, and (3) location of "special" parking lots.

The next subsystem to be given a preliminary inquiry was signing. This included both directional signing and traffic control signing. It was apparent that the direction signing had to play a role in the ultimate solution of the problems generated by the surface street system. The traffic control signs had to be used to maximize the capacity of the available surface streets. Questions as to the acquisition and placement of signs had to be answered.

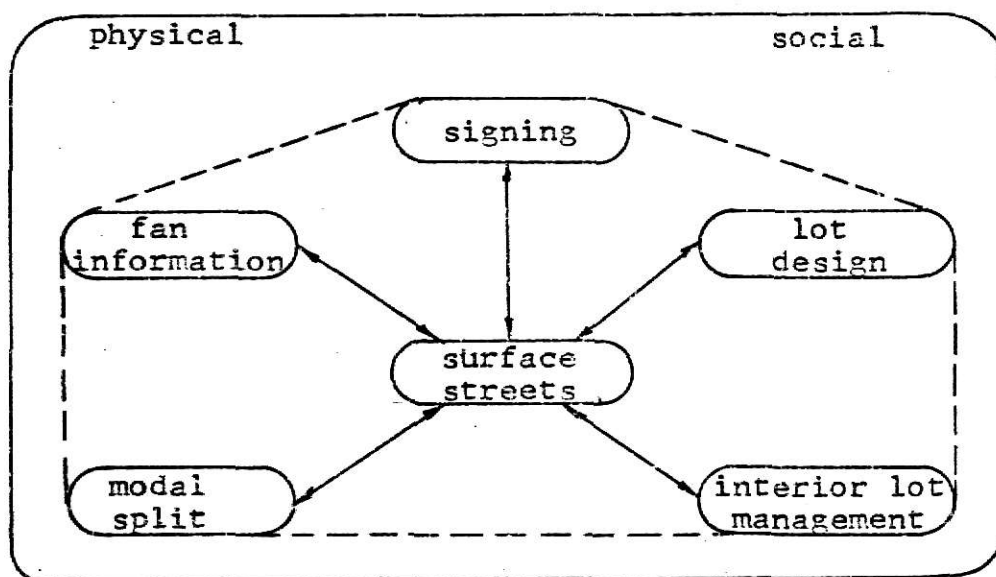
The subsystem entitled fan information was of importance in helping to eliminate the inadequacy of the surface street system. This system had to be designed so that people would make route selections on a basis aimed at equalizing the disproportionate relationship between arrival demand and surface street facilities.

The interior-lot management subsystem had to be designed so as to handle the maximum flow the surface streets could generate. This subsystem could not be a limiting factor or bottleneck in the entire system. The adequacy of the interior lot management system was related to personnel both according to number and ability.

The environment of this system defined itself in terms of physical and social elements. The physical elements were the streets not directly related to the stadium traffic, i.e. those streets other than the five stadium feeder streets. Socially the environment was defined as the attitudes of the public toward the recommendations generated.

Figure 5 shows the relationships among the six subsystems and their environment. The surface street subsystem served as the central focal point because it had the greatest constraining influence. The double arrows indicate the feedback effects.

Diagram demonstrating relationship between
subsystems and their environment
(Figure 5)

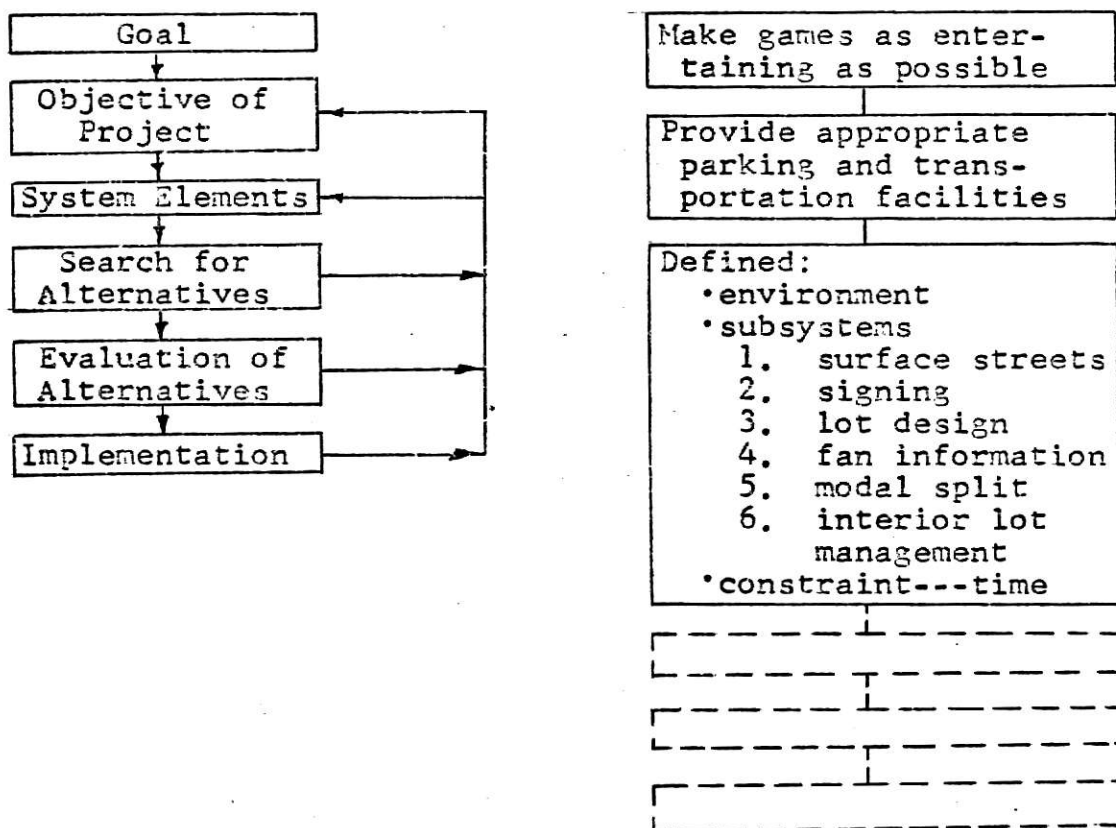


The preliminary overview of the subsystem involved was necessary in order to generate a set of subsystems criteria, limitations, and constraints to be used in the development of

a set of alternatives. This defines the third step in the systems process, "systems elements."

For this study the alternatives were generated within the subsystems. This was done to show the decision makers involved various possible precedures and solutions that could be followed and their effects on the overall system. When the continuum of the subsystem alternatives was developed the total system, in effect, had a continuum of possible alternatives. This continuum could thus be searched for the best alternative.

Diagram of process through
the "system elements" step
(Figure 6)



Each of these systems was approached in depth by means of the systems process. Steps three and four, "Systems elements" and "Search for Alternatives" (fig. 6) were negotiated for each of the subsystems. The use of feedback elements from one subsystem to another acted to integrate the parts into a total system. The criteria, constraints, and limitations from the preliminary inquiry served as preliminary "system elements" in step three of the process.

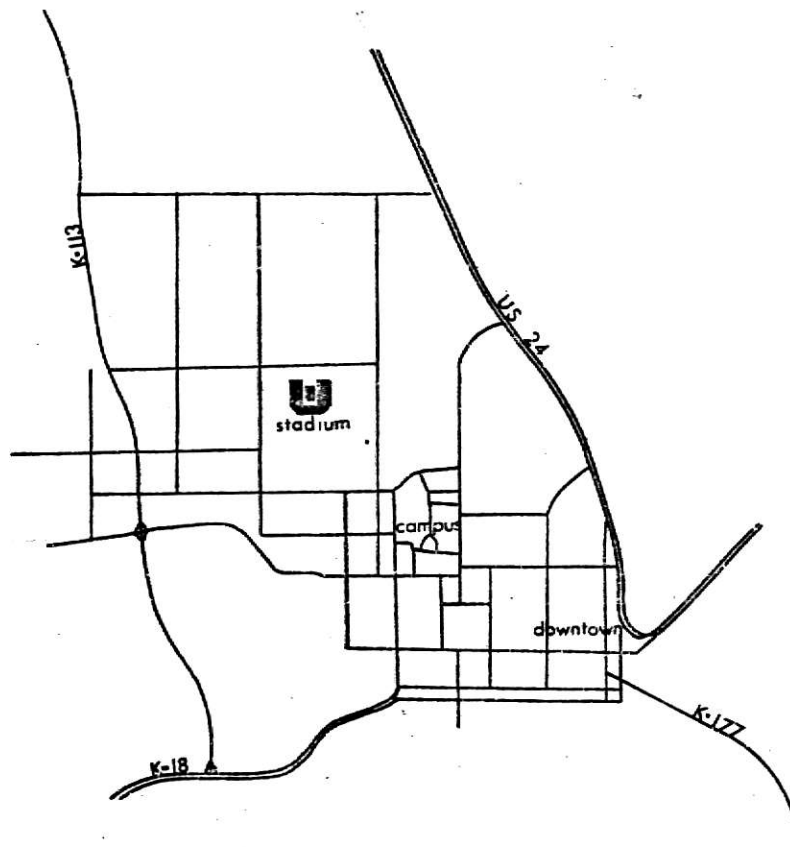
SEARCH FOR ALTERNATIVES

Systems Elements of the Surface Street System

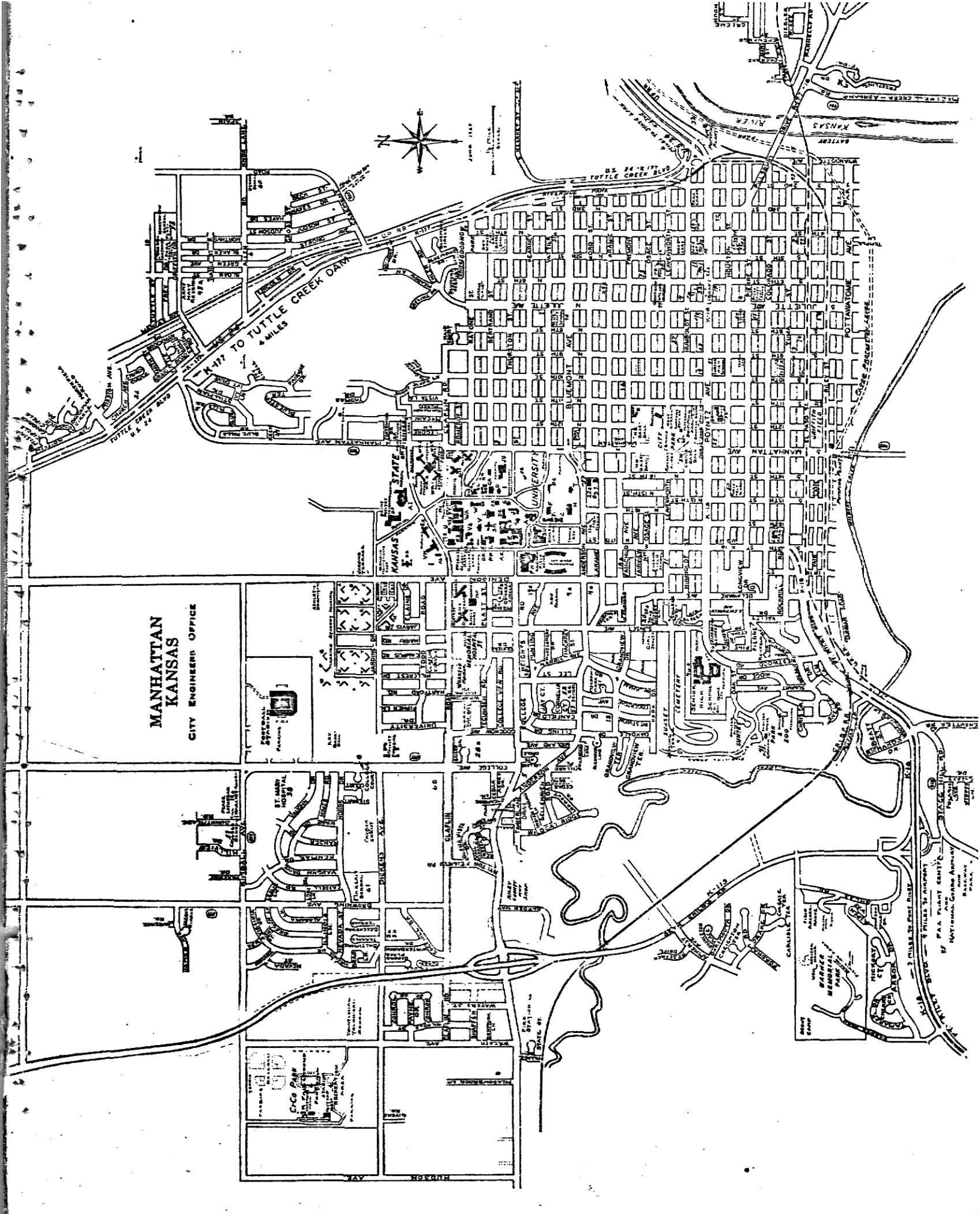
It was felt that the surface street system surrounding the stadium would not be adequate to handle the expected volume.

As stated earlier a major problem existed in the uneven distribution of lanes in regard to travel desires. A substantial

Orientation of KSU Stadium with respect
to the city of Manhattan
(Figure 3)



Orientation of KSU Stadium with Respect
to the complete Street system of the city of Manhattan
PLATE I



percentage of the vehicles that would use the facility would originate from and be destined to the city. The main part of the city was located south and east of the stadium. The figure on the preceding page is a pictorial representation of the situation.

In order to determine the number of vehicles that would demand access to the stadium and the possible time distribution of vehicular arrivals a study of the old stadium traffic was undertaken.

As shown in Table 1 nearly all of Kansas State's 12,000 students wishing to attend the games at the old stadium lived within a one mile radius of that facility. The table also shows that a large percentage of non-students attending the games also lived within this area. To a large number of people concerned (particularly among the students) it was assumed for this study that this distance represented an acceptable walking distance under normal conditions. The central location of the old stadium with its good sidewalks accounted for the high fraction of the attendance arriving on foot.

The lot space at the old stadium was deceptive. It was true that the parking lots adjacent to the old stadium held only 1,500 vehicles but other lots besides these were used. The total number of university lot spaces used, as estimated by the Chief of Campus Police, was 2,200. These spaces coupled with the large number of spaces available (estimated at 1,100) on surrounding surface streets within a radius $5/8$ mile gave

Result of Study Comparing available parking spaces
and walking distances to the old Memorial Stadium
and the KSU Stadium
(Table 1)

Walking Distance Old Stadium		Walking Distance New Stadium	
Students		Students	
3/8 mile	2,900	3/8 mile	300
1/2 mile	1,500 <u>to</u> 4,400	1/2 mile	500 <u>to</u> 800
1 mile	4,000 <u>to</u> 8,400	1 mile	2,700 <u>to</u> 3,500
Non-Students		Non-Students	
3/8 mile	400	3/8 mile	---
1/2 mile	600 <u>to</u> 900	1/2 mile	150
1 mile	1,600 <u>to</u> 2,500	1 mile	300 <u>to</u> 500
Total Number of --- 10,900 People Walking		Total Number of --- 4,000 People Walking	
Parking Space Old Stadium		Parking Space New Stadium	
(paid) lot spaces	1,500	lot spaces at	5,720
at 3.5 occ/veh	5,300	3.5 occ/veh	20,000
surfaced streets		lot spaces	
(5/8 mile at	1,100	(reserved	1,115
3.5 occ/veh)	3,900	at 3.5 occ/veh)	3,900
other lots filled	700	surface streets	
(3.5 occ/veh)	2,500	(5/8 mile at	400
		3.5 occ/veh)	1,400
Total Number of --- 11,700 People Parking		Total Number of --- 25,300 People Parking	
Total 23,000		Total 29,300	

a total of 3,300 parking spaces readily available. With a pressurized parking occupancy of 3.5 occ/veh it can be shown (table 1) that nearly 12,000 people could thus be served.

Thus it could be said that the old stadium location had several desirable features.

- The central location made it more readily accessible on foot. This was true with respect to both distance and walkways available.
- The surrounding surface streets werved the dual purpose of handling the excess parking and the drop-off-and-park type of arrivals.

The above features did not exist to any significant extent at the new facility. The fringe location precluded the large pedestrian traffic, (table 1). The lack of adequate walkways further hindered this mode of travel. The surrounding surface street system was quite sparse even at a radius of one mile. It was assumed that this fact would limit the use of surface streets with respect to both surface parking and drop-off-park arrivals.

Given this information it was possible to estimate the vehicular demand. Assuming an acceptable walking distance of one mile for students and 5/8 mile for non students the number of pedestrian arrivals was estimated to be approximately 4,000. Assuming a capacity crowd of 35,000 it was anticipated that 31,000 people would arrive by auto. Using 3.5 occupants per vehicle this number of people would generate a possible demand of nearly 9,000 vehicles.

The time distribution of arrivals at the old stadium, as stated by University Officials, depended on various factors:

(1) weather, (2) opponent, and (3) student - non-student. Bad weather had a tendency to delay arrivals. An attractive opponent, on the other hand, had a tendency to create earlier arrivals. The degree of the fluctuation was dependent on the classification student or non student since students had no reserved seats.

It was assumed that the weather would be good and the opponent attractive. Under those conditions the non-students five minute peak arrival period was estimated to occur near 1:00 P.M. (1:30 game time). It was estimated that 80% of the fans would arrive at the stadium in the forty-five minute period from 12:30 to 1:15. The student five minute peak usually occurred about 12:45 at the old stadium with a forty-five minute 80% arrival period between 12:20 and 1:05. These figures were assumed to apply to the new facility.

If these distributions accurately reflected the situation at the new stadium 7,300 vehicles would demand access to the new facility within a forty-five minute period under a capacity crowd condition. Expanding this number to an hourly volume yields a peak hour demand of nearly 10,000 veh/hr.

The demand indicated that the capacity of the surface streets was of critical concern even with an equal distribution of arrivals on the available streets, (five lanes at 2,000 veh/hr/lane = 10,000 veh/hr). This is an over simplification of the real-life situation, generated by using an ideal distribution of arrivals and the Highway Capacity Manual's¹⁰ volume at capacity of 2,000 veh/hr/lane. This idealistic

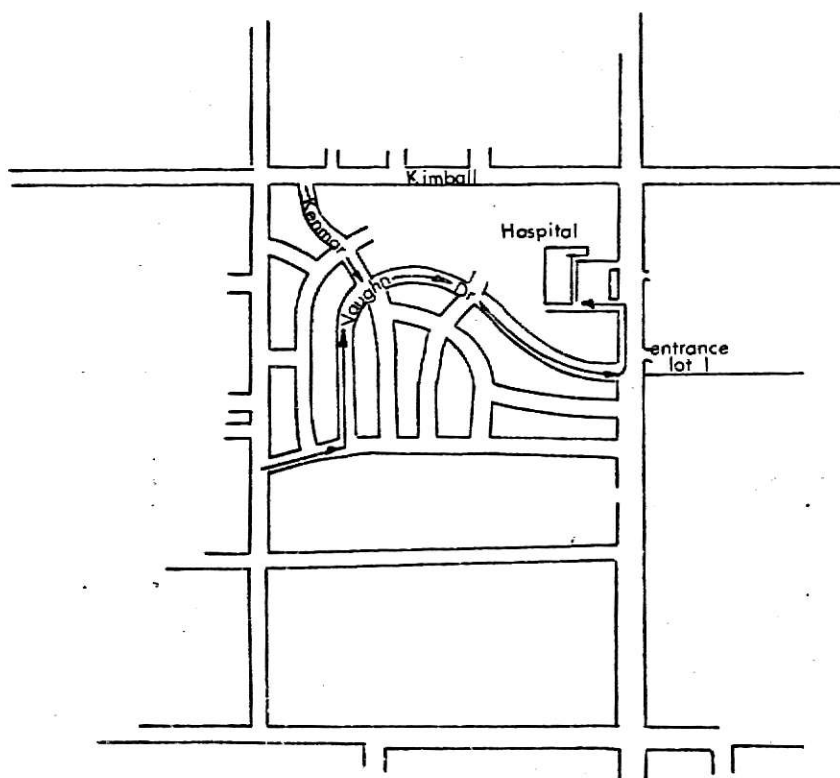
approach demonstrates the critical nature of the surface street capacity problem. If the surface streets were forced to operate at capacity with the ideal distribution, the "real" distribution would surely overtax the system.

The demand for exiting after the game presented a problem somewhat different from that posed by the entrance demand although it was of equal importance. In developing the exit demand volume it was assumed that the time period involved would be thirty minutes. That is to say all vehicles in the lot would demand exit within one-half hour after the game. With 6,835 spaces available in the lot this created an expanded volume of 13,670 vehicles per hour. This volume was higher than the entrance demand but the distribution of exits could be controlled to insure a nearly equal distribution to the available routes. This ability decreased the adverse affect of the disproportionate entrance demands.

Special problems were anticipated at the entrance to lot 1. This entrance was to serve 1,335 surfaced spaces and an additional 750 unsurfaced spaces (2,085 total spaces). The entrance was serviced by the main route providing access to St. Mary's Hospital for emergency vehicles (see fig. 9).

The large number of vehicles to be handled by this entrance, served by only one access route, indicated that the capacity of the access route would limit the number of spaces filled before game time. Expanding the number of vehicles that could be served through this entrance according to the assumed

Surface street relationship between
St. Mary's Hospital and Lot 1 entrance
(Figure 9)



entrance demand distribution yielded a volume of 2,800 veh/hr. Operating at 1,000 veh/hr/lane with two lanes it would take nearly one and one half hours to handle the expected demand. Since 80% of the entrance demand was estimated in the 45 minute period from 12:30 to 1:15 it could be seen that the lot spaces available would not be occupied until 2:00 o'clock, 1/2 hour after the start of the game. This, of course, was judged to be totally unacceptable.

As stated the second major problem at this entrance involve the possibility of conflict with emergency vehicles destined for the hospital. It was deemed necessary to provide these vehicles with a special exclusive access route to the hospital. This could be done by assigning a route to the emergency vehicle through the residential area west of the stadium (see fig. 9).

There was also a problem concerning the entrance to lot 2. This entrance served a special reserved lot, admittance to which could be gained only by the possession of a special parking permit. The difficulty involved was related, again, to the lack of circulation around the stadium. That is, patrons with the privilege of parking in this lot who would arrive from the east would have a great deal of difficulty in reaching this entrance because they would be traveling against the flow of traffic. The solution to this problem rested in the use of information to educate patrons as to the most desirable routes to this lot.

Through this inquiry certain problems were uncovered.

These problems were:

1. Disproportionate entrance demand distribution and lack of surface street capacity to handle peak demand.
2. Management of exit volume to utilize available street capacity.
3. Lack of circulation around stadium.
4. Problems of access for special reserved lot.
5. Special access route for emergency vehicles.

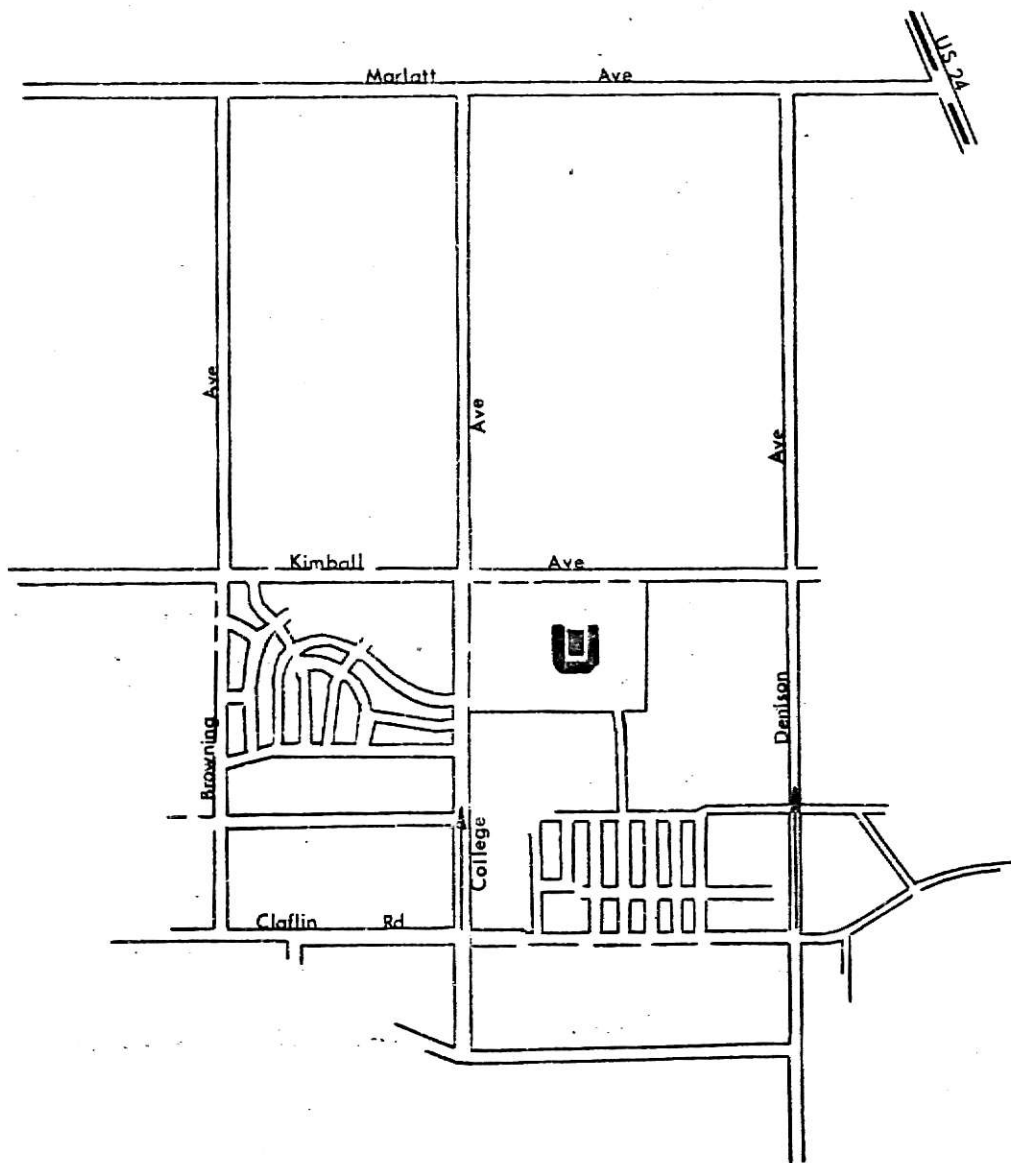
Search for Alternatives for the Surface Street System

As stated previously these were rigid constraints in that no time was available prior to the first usage of the new

football facility to initiate a large construction program. The solution to these problems had to be handled by means of feedback within the other subsystems.

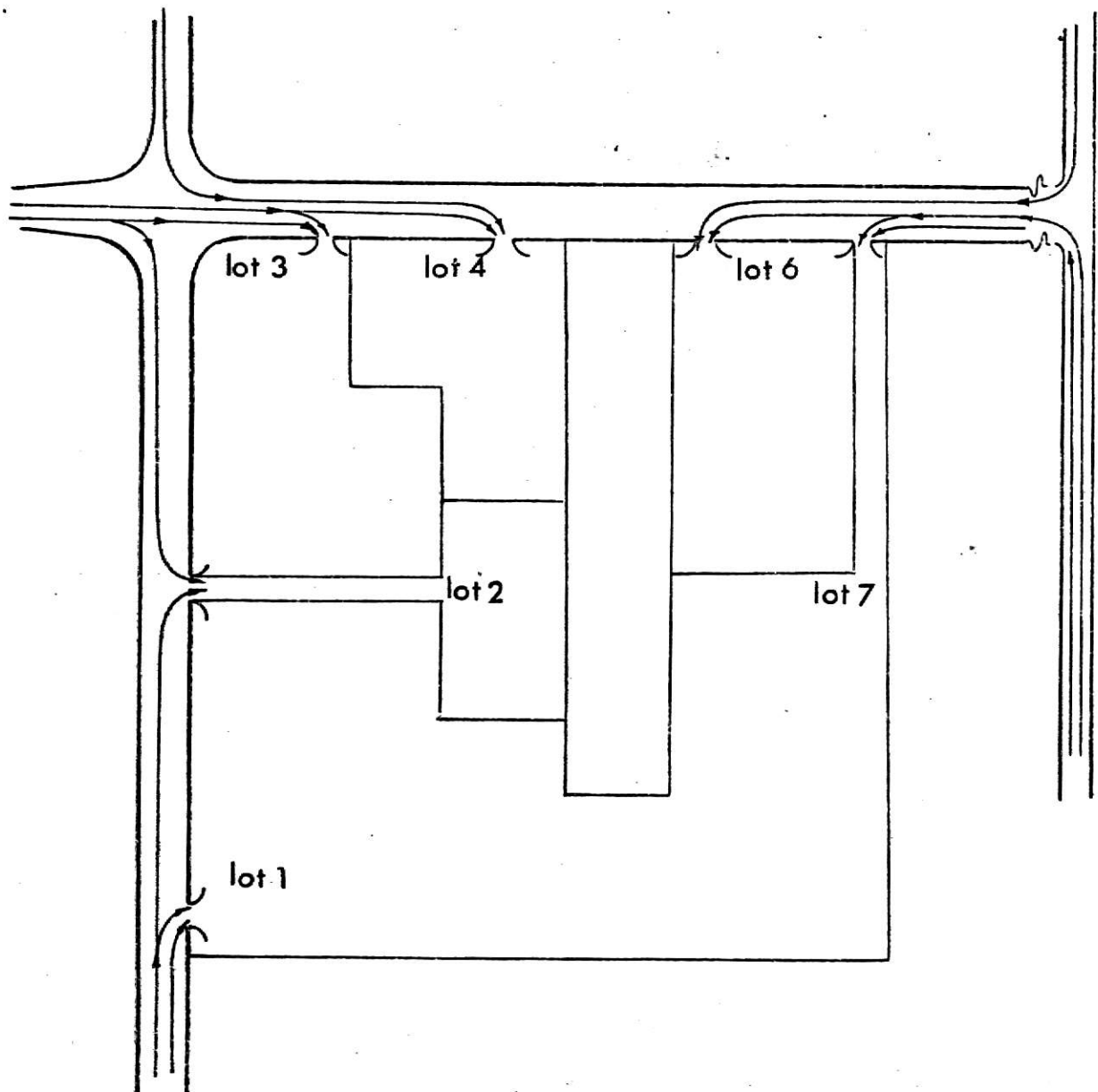
The main arrival demand was expected to occur on College Ave. and Denison Ave. as shown by the arrows (fig. 10). To

The surface street system
surrounding the new stadium
(Figure 10)



handle this demand it was important that these routes operate at maximum capacity. This required that they must be made one way north prior to the game (fig. 11). Other control measures, such as parking restrictions, should also be implemented along all major access routes.

The most advantageous entrance operation
(Figure 11)



It was estimated that the other access routes, College Ave. south, Denison Ave. south, and Kimball Ave. east, of the stadium would not carry a sufficient volume to warrant being made one-way. Their usage however had to be made attractive by fan information to help relieve flow on the two primary routes.

To handle the exit volume maximum usage had to be made of the available exit routes. To accomplish this a specific routing plan according to the location and capacity of the parking lots had to be initiated. Figure 12 depicts an example of such a plan.

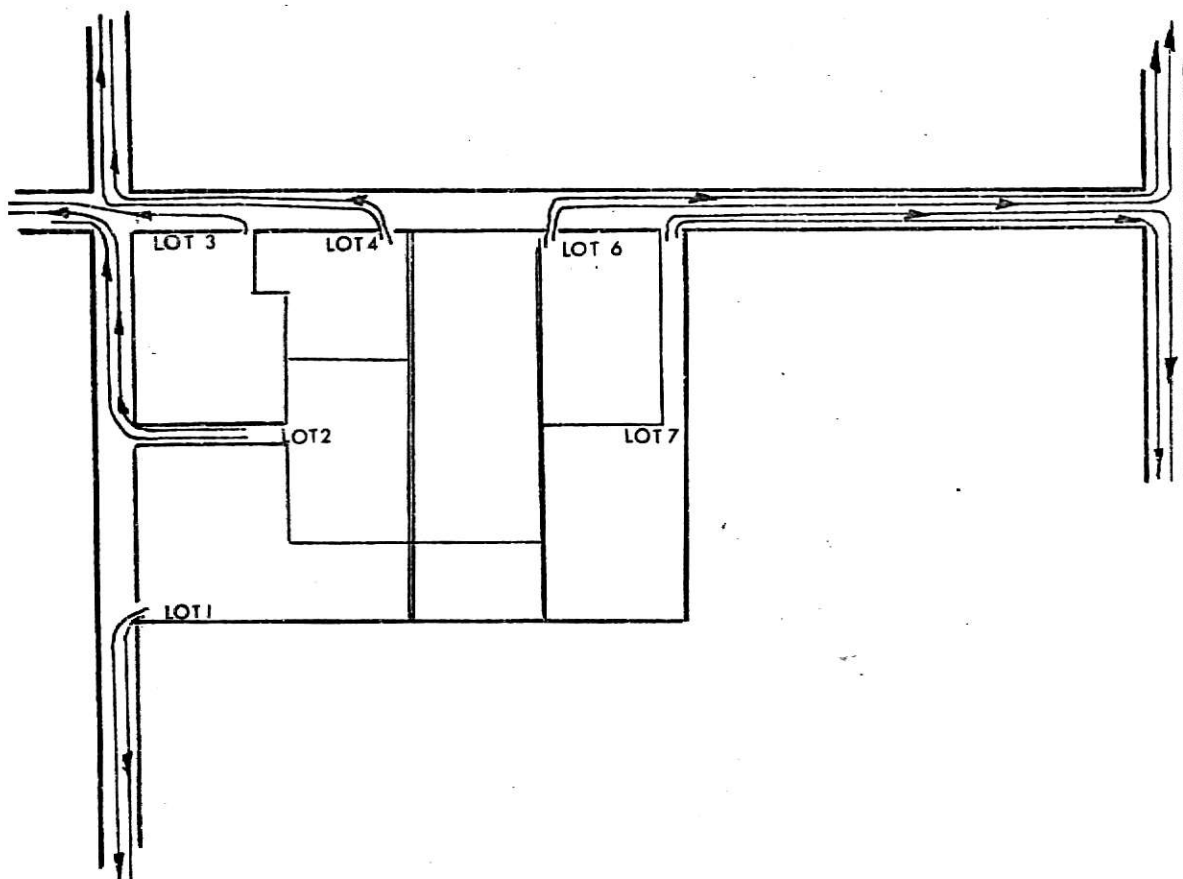
To facilitate movement all the major routes away from the stadium had to be made one-way. (See Figure 12) Specifically these routes were:

1. College Ave. between Claflin Road and Entrance 1--
one-way south
2. Kimball Ave. between Entrance 4 and K-113--
one-way west
3. College Ave. between Entrance 2 and Marlatt Ave.--
one-way north
4. Denison Ave. between Claflin Rd. and Kimball Ave.--
one-way south
5. Denison Ave. between Marlatt Ave. and Kimball Ave.--
one-way north

The lack of circulation was a problem of such magnitude that it bordered on being critical. This lack of circulation became most apparent in studying two areas of the traffic flow. These problem areas were: (1) problems of queue build up, and (2) problem of special reserved lot access.

Assuming the unequal distribution of arrivals it was apparent that queueing would take place. In view of the objective of providing appropriate transportation facilities

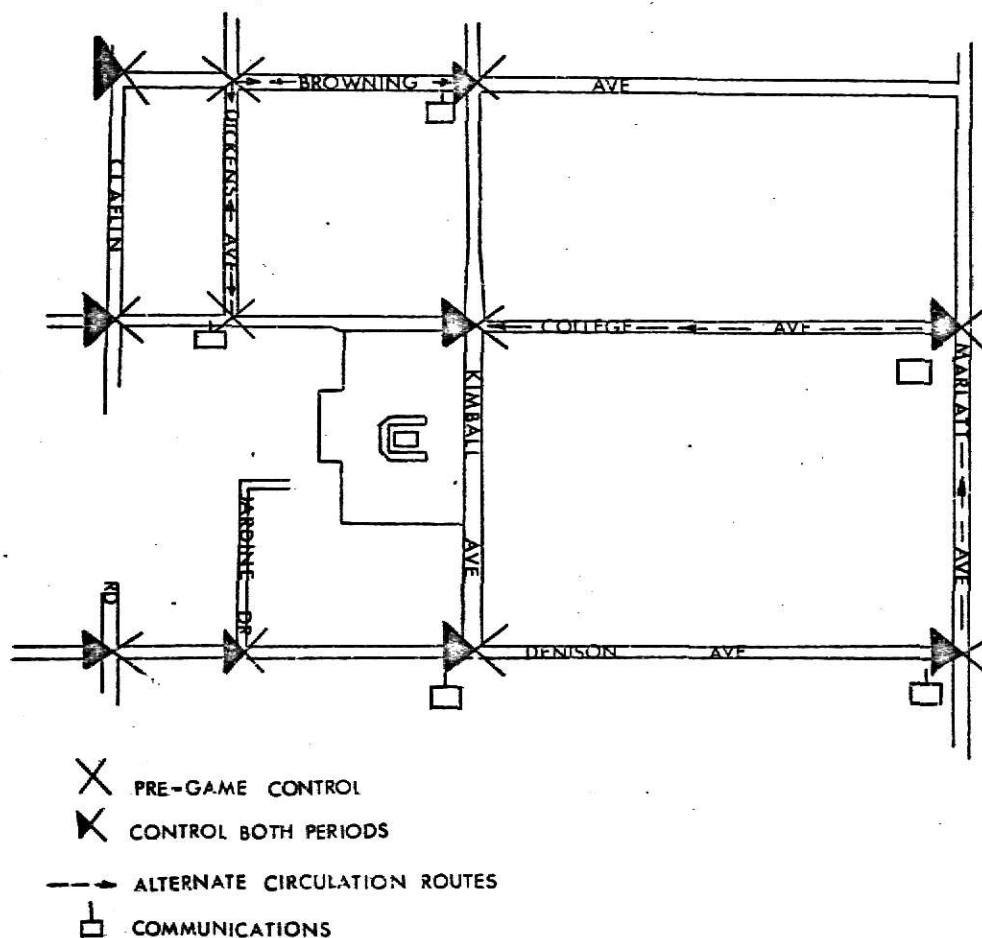
The most advantageous exit operation
(Figure 12)



it was important to maintain a minimum queue length. It was proposed that certain key intersections be in radio communication with a control point and that these intersections operate to redirect traffic if need should arise. The intersections were:

1. Browning Ave. and Kimball Ave.
 2. Dickens Ave. and College Ave.
 3. Marlatt Ave. and Denison Ave.
- (See Figure 13)

Radio controlled intersections
and routes for redirection
of traffic
(Figure 13)



In essence these locations were points of control to be used to equalize demand between the various routes in accordance with lot spaces available. For instance, if more people used the highway access routes than expected and the space in lot 1 was not being filled then traffic would be directed down Dickens Ave. or Claffin Road then down Browning Ave. thence east on Kimball Ave. A similar situation existed on the Denison, Marlatt, and College Avenue system. If

Denison Ave. was carrying more traffic than it should, traffic attempting to enter Denison Ave. from Marlatt Ave. had to be directed to College Ave.

In addition to these points of radio control other key intersections had to be managed by police personnel to insure steady and safe flow. These intersections were:

1. College Ave. and Kimball Ave.
2. Marlatt Ave. and College Ave.
3. Dickens Ave. and Browning Ave.
4. Claflin Rd. and Browning Ave.
5. Claflin Rd. and College Ave.
6. Claflin Rd. and Denison Ave.
7. Denison Ave. and Jardine Dr.
8. Denison Ave. and Kimball Ave.

It was important that several of these locations also have radio communications. These locations were:

1. Marlatt Ave. and College Ave.
2. Dickens Ave. and College Ave.
3. Kimball Ave. and Browning Ave.
4. Denison Ave. and Marlatt Ave.
5. Denison Ave. and Kimball Ave.

The exit flow necessitated a somewhat different placement of police personnel. It was recommended that on the exit flow, officers be placed at the intersections of Marlatt Ave.-US 24 and Kimball Ave.-K-113. In addition to these the same intersections cited above for control of entrance traffic had to also be manned by police personnel for control of exit flow. The exceptions were the intersections of Dickens Ave.-Browning Ave. and Dickens Ave.-College Ave. from which police control was deleted for the exit flow operation.

The second problem arising from the lack of circulation, routing to the special reserved lot, could best be handled by information made available to fans. It was not in accord with

the objective of this study to provide preferential treatment to special groups during arrival periods. It was not out of line to suggest that some of those vehicles destined for the special lot be allowed to park in another lot if their flow to the special lot would be detrimental to the overall traffic flow.

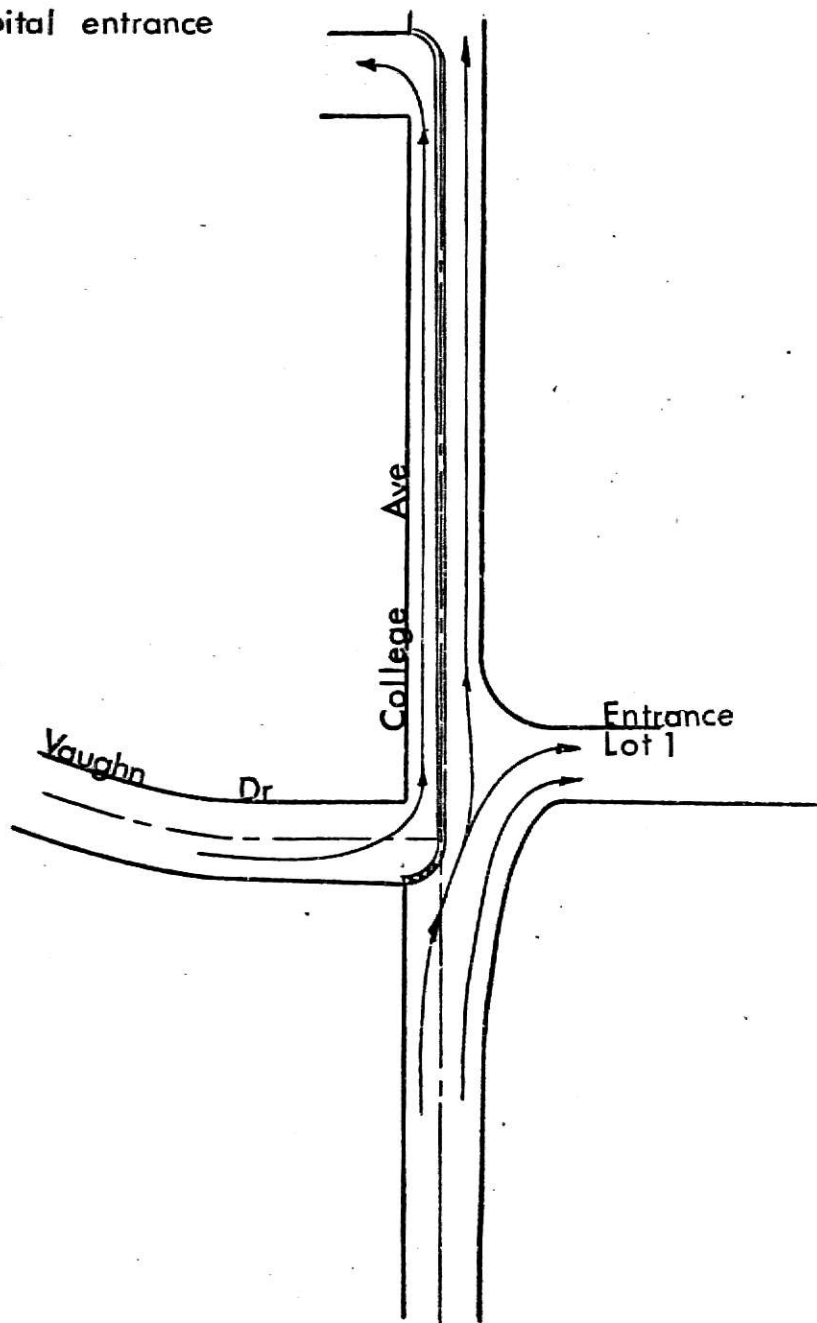
Another problem presented by the crowded surface streets surrounding the new stadium was the possible interference with emergency vehicles destined for St. Mary's Hospital during the entrance and exit flow. The best possible solution to the problem was to provide the emergency vehicle with a route, relatively free of game-destined vehicles, through the residential area to the west of the stadium. Even if this were done however the emergency vehicles would have to eventually enter College Ave. to gain access to the Hospital. If Vaughn Drive, located opposite entrance 1, were designated as the emergency vehicles route, a lane on College Ave. could be reserved for emergency use without conflicting with the overall traffic flow. (See Figure 14)

In summary the following is a list of recommendations that were made:

1. College Ave. between Claflin Rd. and lot entrance 2 be made one-way north prior to game time (effective at 12:30 or when traffic warrants such action)
2. Denison Ave. between Claflin Rd. and Kimball Ave. be made one-way north prior to game time (effective at 12:30 or when traffic warrants such action)
3. Parking restrictions on major routes
4. Use of fan information to stress attractiveness of highway routes (US 24-K 177 and K-113)

Provisions for emergency vehicle
flow at intersection of Vaughn Dr.
and College Avenue
(Figure 14)

Hospital entrance



5. Post game one-ways
 - a. College Ave. between Claflin Rd. and entrance 1
one-way south
 - b. Kimball Ave. between entrance 4 and K-113
one-way west
 - c. College Ave. between entrance 2 and Marlatt Ave.
one-way north
 - d. Denison Ave. between Claflin Rd. and Kimball Ave.
one-way south
 - e. Denison Ave. between Marlatt Ave. and Kimball Ave.
one-way north
6. Police controlled intersection (pre-game)
 - a. Kimball Ave. and Browning Ave. --- communications
 - b. Dickens Ave. and Browning Ave. --- "
 - c. Claflin Rd. and Browning Ave. ---- "
 - d. Claflin Rd. and College Ave. ----- "
 - e. Dickens Ave. and College Ave. ----- "
 - f. Kimball Ave. and College Ave.
 - g. Marlatt Ave. and College Ave. ---- communications
 - h. Marlatt Ave. and Denison Ave. ---- "
 - i. Kimball Ave. and Denison Ave. ---- "
 - j. Jardine Dr. and Denison Ave. -----
 - k. Claflin Rd. and Denison Ave. -----
7. Police controlled intersection (post-game)

same as above except for deletion of control at:

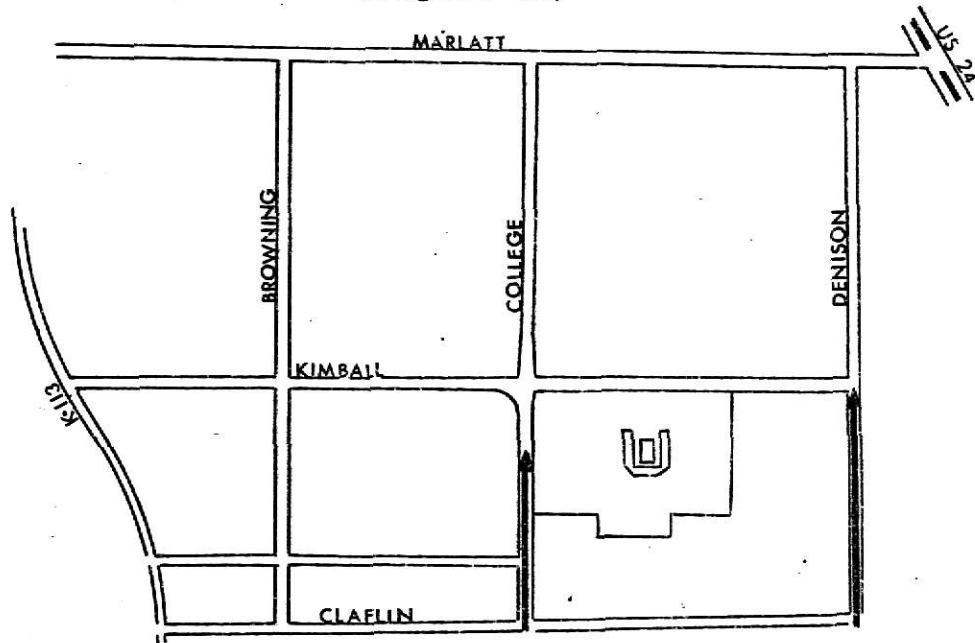
 - a. Dickens Ave. and Browning Ave.
 - b. Dickens Ave. and College Ave.

with the addition of control at:

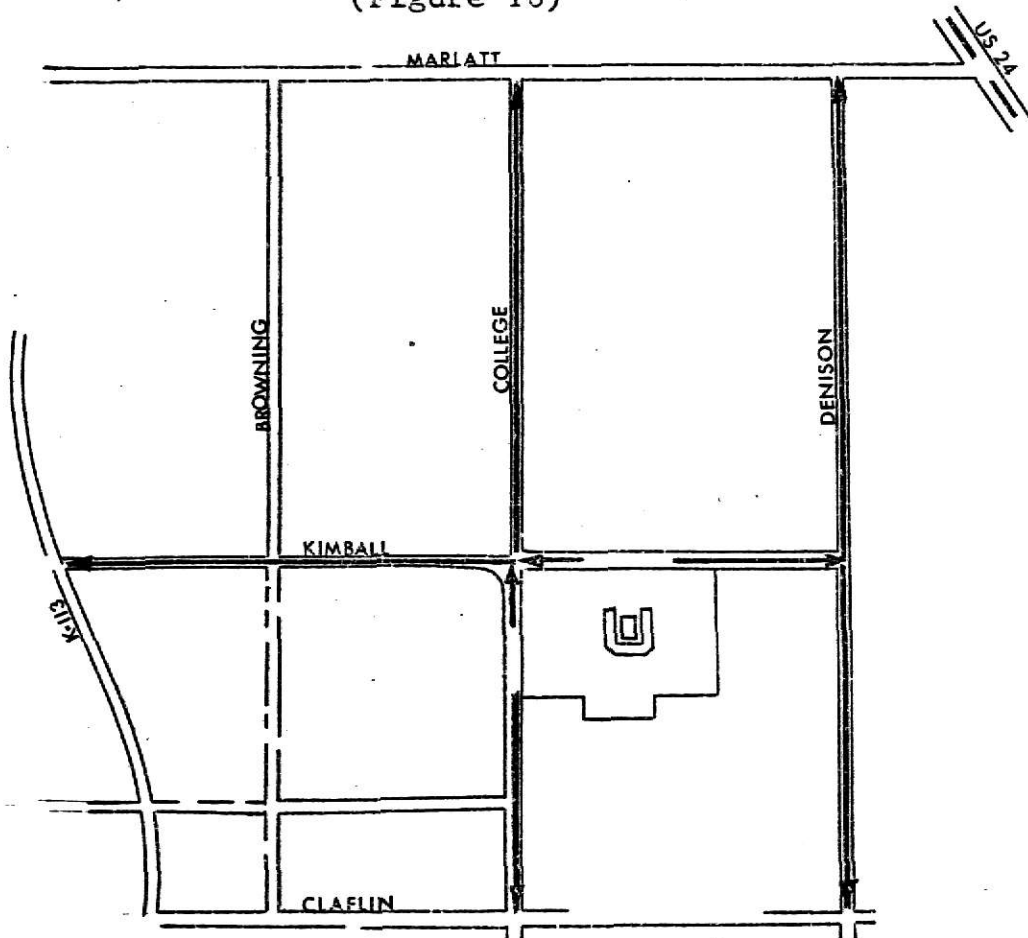
 - a. Kimball Ave. and K-113
 - b. Marlatt Ave. and US 24
8. Reservation of exclusive emergency lane on College Ave.
from Vaughn Dr. to Hospital entrance.
9. Fan information providing most desirable routes to
special reserved lot.
10. Entrance and exit patterns to maximize use of facility.
11. Capacity of routes will limit number of lot spaces
that can be used.
12. Advise people of need to arrive early to decrease
peak distribution.

(To bring these recommendations into proper perspective refer
to figures 11, 12, 13, 14, 15, and 16.)

Streets to be made one-way for pre-game operations
(Figure 15)



Streets to be made one-way for post-game operations
(Figure 16)



Note: It is necessary here to restate that these recommendations represent a continuum of possible alternatives. That is, possible decisions ranging from the do nothing alternative to the implementation of all the recommendations exists. It was assumed that all these recommendations would be accepted. This information was used then as feedback into the inquiry of the other subsystems.

System Elements of the Modal Split System

The next inquiry conducted involved the subsystem concerning modal split. This inquiry was initiated with feedback information from the previous study. This information was:

1. Estimation of 4,000 arrivals on foot
2. Possible decrease of 750 parking spaces from the planned 6,835 spaces because of street capacity.
3. Possibility of nearly 9,000 vehicles with maximum attendance.
4. General overcrowded condition of surface streets.

From this feedback it was apparent that with a capacity crowd of 35,000 people that nearly 2,900 vehicles would demand entrance to the lot without having spaces in which to park. Surface street parking within an acceptable walking distance would handle only 500 vehicles. This would leave nearly 2,400 vehicles without appropriate parking facilities.

Clearly the primary problem was to handle the excess vehicles appropriately. Along with this there was a secondary problem of implementing this subsystem.

Search for Alternatives for the Modal Split System

Access to the new facility was limited to three possible modes. The possible modes were: (1) passenger vehicles (2) walking (3) buses.

It was important to optimize the useage of all of these modes. The passenger vehicle was, of course, the most important mode. Maximum use of the parking spaces available in the lot and on the surface streets was important therefore to gain the best results from passenger vehicles.

The estimated vehicular demand was generated assuming an occupancy rate of 3.5 occupants/vehicle. This number was a rather high value resulting from a facility that by its lack of surface streets and parking had created a pressured situation. The KSU stadium being new was not known to be pressured, therefore there was some doubt as to the validity of the above figure in regard to this facility. A lower vehicle occupancy might more accurately reflect the true situation at the new facility. This would be in direct contradiction to efforts to maximize the use of the available parking space, for every one-tenth decrease from this number another 200 vehicles would be imposed on the system. It was necessary therefore to pressurize the facility so that a high occupancy (approaching 3.5) was insured.

It was thought that the highest possible occupancy could be gained by: (1) restricted student parking and (2) staggering pricing in inverse relationship with the passenger-car occupancy.

This restriction could be managed best by selling coupons on a first-come-first-serve basis. A logical number of student spaces thus made available would have been 1,500. (A student attendance of 9,000 is anticipated. Of this number

4,000 were within an area acceptable to the walking mode under good weather conditions. This left 5,000 students that had to take another mode. If all of the students drove, approximately 1,500 parking spaces would be demanded at 3.5 occupants per vehicle. Taken as a group students comprised $9/35$ of a capacity crowd. Applying this fraction to the available parking (5,385) it could be seen that the proposed 1,500 spaces for student parking was a fair proportionate share.)

It was proposed that compliance to this restricted parking be enforced by giving tickets to the offenders. The best method of handling violators would have been rejection from the queue. It was quite possible, however that this could not have been done without a traffic tie-up.

Pressurizing the student parking space without an effort to maximize the efficiency of the remaining part of the lot would have been only a partial solution. It was proposed that the remaining parking spaces (3,435) be made available on a staggered price based inversely on vehicle occupancy. Prices recommended are as follows:

- A. \$1.50 for drivers only
- B. \$1.00 for driver with one or two passengers
- C. \$.50 for driver with three or four passengers
- D. Free for driver with five or more passengers

The purpose of these measures was to insure an appropriate vehicle occupancy and was not meant to solve the overall traffic problem. It would however help influence the number of people choosing a mode other than passenger vehicles. It was felt these measures would also increase the average occupancy.

It was believed that the best solution to the problem of handling the surplus was the use of shuttle buses. The efficiency of buses can be demonstrated by the fact that one bus trip is the equivalent of twenty passenger cars.

The basic idea behind this effort was to remove traffic and parking from the area surrounding the new stadium by directing it to other areas then providing shuttle service from these areas to the stadium.

Shuttle transfer points were best placed in the following locations:

1. West Loop Shopping Center off K-113
2. Blue River Hills Shopping Center off US 24
3. Student Union
4. "West Stadium" parking lot (West of the old Stadium on Campus)
5. University Dorm Complex (on campus)

The desirability of this service had to be stressed if it were to operate at the level deemed necessary. Promotional efforts by the Student Union and others concerned had to be undertaken. The specifics of this plan were dependent on the anticipated demand. It was quite possible that the system could operate as follows:

1. Two buses one trip each at the West Loop shopping center generating 100 people.
2. Two buses one trip each at the Blue River Hills shopping center generating 100 people.
3. Twelve busses making three trips to the dorm complex generating 2,000 people.
4. Four buses at the Student Union making two trips generating 400 people.
5. Fifteen buses at West Stadium each making two trips generating 2,000 people.

This proposal relieved only 4,600 of the expected 8,400 people not provided with appropriate transportation facilities.

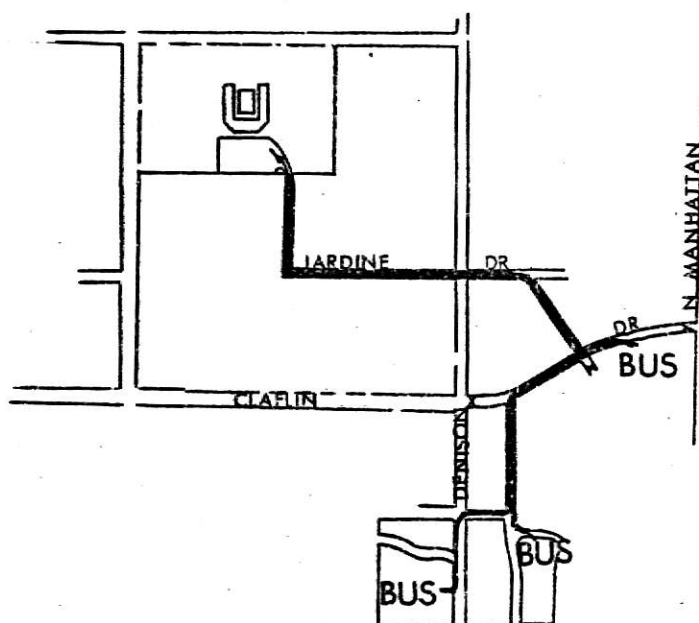
To increase this operation the number of trips each bus would make had to be increased, as the total number of buses available to run this operation was limited.

To facilitate the movement of buses to the stadium a special exclusive route was proposed through the campus. It was important that this route be provided to insure a good level of service by this mode.

The following is a summary from the inquiry into the modal split subsystem.

1. Limitation of student parking to 1,500 vehicles available by coupons on first-come-first-serve basis.
2. Staggered price scale on remainder of lot varying inversely with occupancy. (see text for scale)
3. Use of shuttle bus service operating from five locations (locations and number of operating buses in text)
4. Restricted access on north part of campus to provide exclusive bus route (see Fig. 17 for route)

Proposed Exclusive Shuttle Bus Route
(Figure 17)



System Elements of the Lot Design System

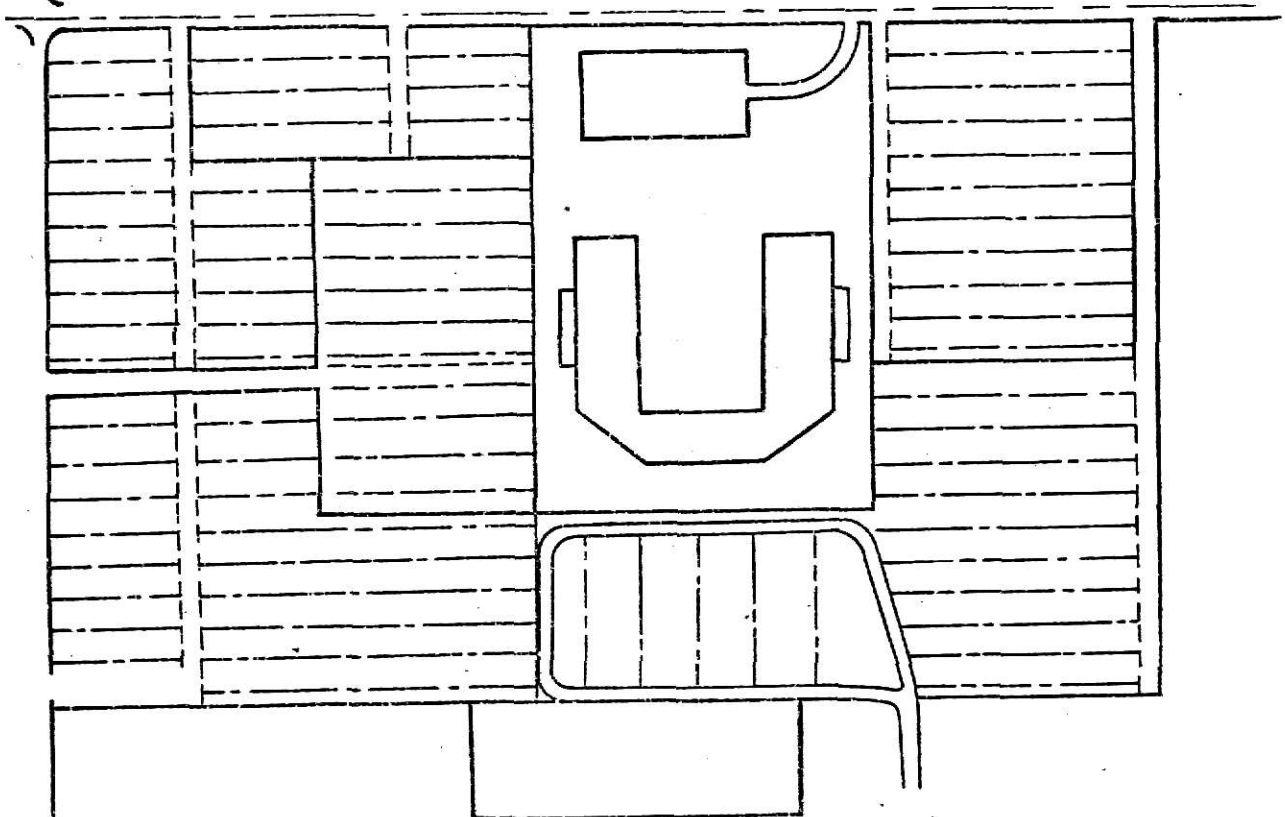
The inquiry into the lot design was necessary because it was planned and construction started before this study was initiated. It therefore had to be considered as a subsystem.

From the preceding subsystem feedback the following constraints were generated.

1. 1,500 space lot for students
2. 800 spaces in special reserved lot
3. Unusable overflow lot adjacent to lot 1

The final design of the KSU stadium parking lot is shown in figure 18.

Lot Design of KSU Stadium
Parking Facilities
(Figure 18)



This parking facility had eight entrances. Each entrance was 30 feet wide with a 20 foot return radius. It was divided into eight separate lots. Three of these lots were designated for special usage. Lot 1A was an unsurfaced lot intended for use as an overflow lot. Its usage was doubtful however because of the limitation imposed by the capacity of its only access route.

Lot 5 was an employee lot designed to hold 286 vehicles. The lot handled team buses, management personnel, and others who would arrive before the peak period and therefore would not affect the peak period traffic.

Lot 8 was a special lot for buses. It contained 160 spaces and was serviced by an exclusive route through the student housing complex located near the stadium. The lot would be filled only during the game corresponding to the annual "Band Day". At other games part of this lot could be used as an overflow for lot 1.

Lot 2 was a special reserved lot for preferred patrons. In the original design this lot was to contain 1,150 spaces. This number was however higher than the anticipated demand and it was recommended that 350 spaces be removed from this lot and placed in lot 4.

The total number of spaces available was 7,171. This number was broken down as follows.

1. General public 5,335 spaces
2. Non-public (special reserve and employee) 1,086
3. Spaces not usable 750 (because of surface street limitations)

The total number of general public spaces available (5,335) was much less than the figure that was publicized prior to this study. The original figure of 8,500 was in line with the 1 to 4 ratio recommended for design purposes for parking spaces in relation to seating capacity. It was anticipated that the advanced publicity would have the effect of creating a low occupancy. It was therefore necessary through the fan-information system to stress the need to car-pool with friends when attending the game.

Search for Alternatives for the Lot Design System

To provide the 1,500 student spaces it was recommended that lot 7 be expanded to contain this number. Lot 7 was the logical lot to expand. The reason for this was that most of the students would be arriving from the east on Kimball Ave.

The student lot would not be an exclusive lot. That is, if the student lot was not filled by students it would be filled by non-students.

The following is a list of recommendations made resulting from the inquiry into the lot design.

1. Lot 2 (special reserved lot) should be reduced to 800 spaces with the other 350 spaces placed in lot 4.
2. Fan information directed at encouraging car-pooling.
3. Increasing lot 7 to enable it to park 1,500 vehicles for student parking (corresponding decrease in lot 6 to 950 spaces).

System Elements of the Signing System

The inquiries to this point demonstrated a need for both direction and control signing. Specifically the feedback from

other subsystems had generated the following criteria:

1. Parking restrictions on major routes
2. Provide direction to the facility

The above feedback elements were the main criteria for this system. However these criteria operated under the constraints and limitations set down by the Manual of Uniform Traffic Control Devices.¹¹

The Manual¹¹ states that "any traffic control devices should meet five elementary requirements:

1. It should be capable of fulfilling an important need.
2. It should command attention.
3. It should convey a clear, simple meaning.
4. It should command respect of road user.
5. It should be located to give adequate time for response."

These elementary requirements served as constraints for any signing system including the one that was under investigation here.

Regarding the legality of sign placement on highways, the Manual states; "Traffic signs shall be placed only by the authority of a public body or official having jurisdiction for the purpose of regulating, warning or guiding traffic. No traffic sign or its support shall bear any commercial advertising." From this standpoint a major area of concern was the interpretation the Kansas State Highway Department would give the Stadium. Would the State Highway Department view signs guiding traffic to the new stadium as commercial advertising?

Search for Alternatives for the Signing System

Parking on streets surrounding the stadium would affect the flow prior to the game. More importantly however, it would create a severe hazard in the exit operation because of the one-way control for post-game traffic. It was recommended therefore that, on the following routes, no parking would be allowed on either side.

1. College Ave. from Claflin Rd. to Marlatt Ave.
2. Denison Ave. from Claflin Rd. to Marlatt Ave.
3. Kimball Ave. from K-113 to Denison Ave.

In addition to these routes, streets which would serve as major feeder routes should also have similar parking control. Furthermore these streets lacked necessary shoulder width to handle parking. Because of this they warranted parking control exclusive of game generated traffic flow. Therefore in addition to the above major access route, parking control was also recommended on:

1. Dickens Ave. -- K-113 to College Ave.
2. Claflin Ave. -- K-113 to Denison Ave.
3. Marlatt Ave. -- K-177-US 24 to Browning Ave.
4. Browning Ave. -- Claflin Rd. to Hobbs Dr.

Partial or one-side parking control was recommended on:

1. Browning Ave. -west side- Hobbs Dr. to Kimball Ave.
2. Hobbs Dr. -south side- Browning Ave. to College Ave.
3. Vaughn Dr. -south side- Hobbs Dr. to College Ave.
4. Kenmar Dr. -west side- Vaughn Dr. to Kimball Ave.

Partial control on Browning Ave. was recommended because of the high volume that would be carried by this street and the detrimental effect that parking would have on the traffic flow. Hobbs Dr. also was expected to carry a large volume. It was assumed that Hobbs Dr. along with Dickens Ave. would

serve as major release valves for exit flow on College Ave. Control on Vaughn Dr. and Kenmar Dr. was thought necessary because this was the access route to the hospital during the game.

The usage of directional signs was based on the following criteria:

1. Lack of circulation around the stadium lot.
2. Special lots (special reserved lot and student lot).
3. Use of shuttle buses.
4. Legality of right-of-way placement of signs.

The lack of circulation made the use of route signing quite important. The route signing had to be of such a nature as not to lead to confusion on the part of those drivers trying to use the highway access route.

Directional signs to indicate routes to the special reserved lot and the student lots were not necessary. This information was best relayed by fan information. The possible exception to this was the need for a directional lane change sign to serve the special reserved lot. Signs should be located on Kimball Ave. just west of College Ave. and on College Ave. south of lot entrance 1.

The third criteria concerning signing at the new facility was concerned with the use of shuttle buses. If the use of shuttle buses was to reach its full potential adequate signing had to be provided. It should be recalled it was estimated that nearly one-fourth of the attendance must be bused to the stadium if the facility were to offer an appropriate transportation plan.

The placement of commercial signing on the highway right-of-way is not possible. The alternative is to place the sign off the right-of-way. It was felt that the Kansas State Highway Department would allow the placement of its standard information sign on the highway routes.

There were also several locations within the city and county jurisdiction that needed directional signs. It was felt that at these locations signs communicating the recreational spirit of the facility should be used. Part of communicating this recreational spirit would be limiting the word messages as much as possible in favor of standard University symbols.

The question was studied as to whether or not these signs should be temporary. It was felt that the signs serve an advisory service other than direction of game traffic. In addition to this it was apparent that temporary signs would create a problem concerning placement of these signs prior to the game. There was some doubt about the feasibility of erecting permanent signs that satisfy a need during only a small fraction of the year. Making these signs permanent would be detrimental to urban aesthetics and cause confusion surrounding interpretation of more necessary signing.

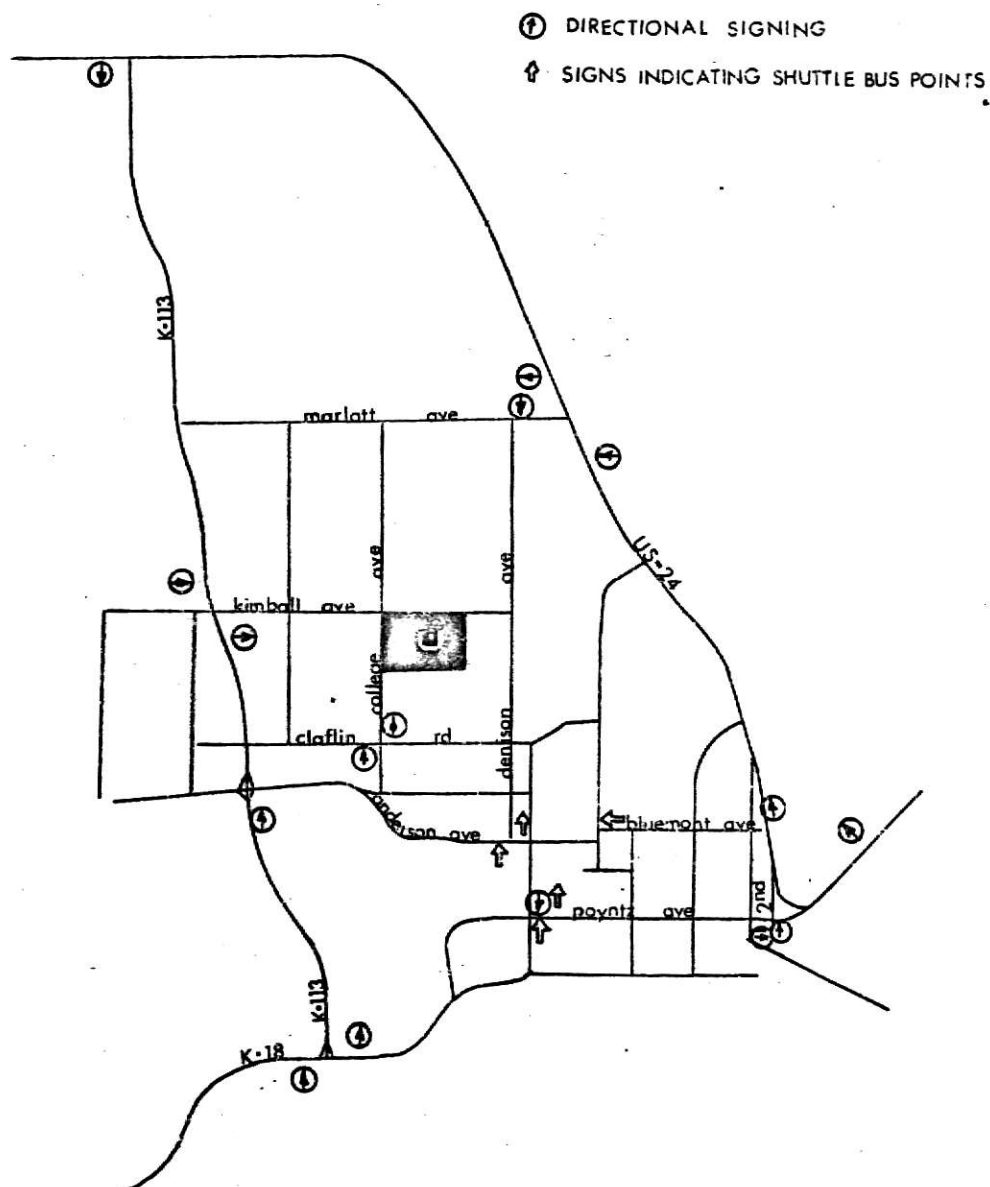
In summary the following recommendations were made.

1. parking restriction on routes important to traffic flow (see fig. 20)
2. directional signs on highways provided by the highway department (see fig. 19)
3. directional signs in city and county (locations on map)

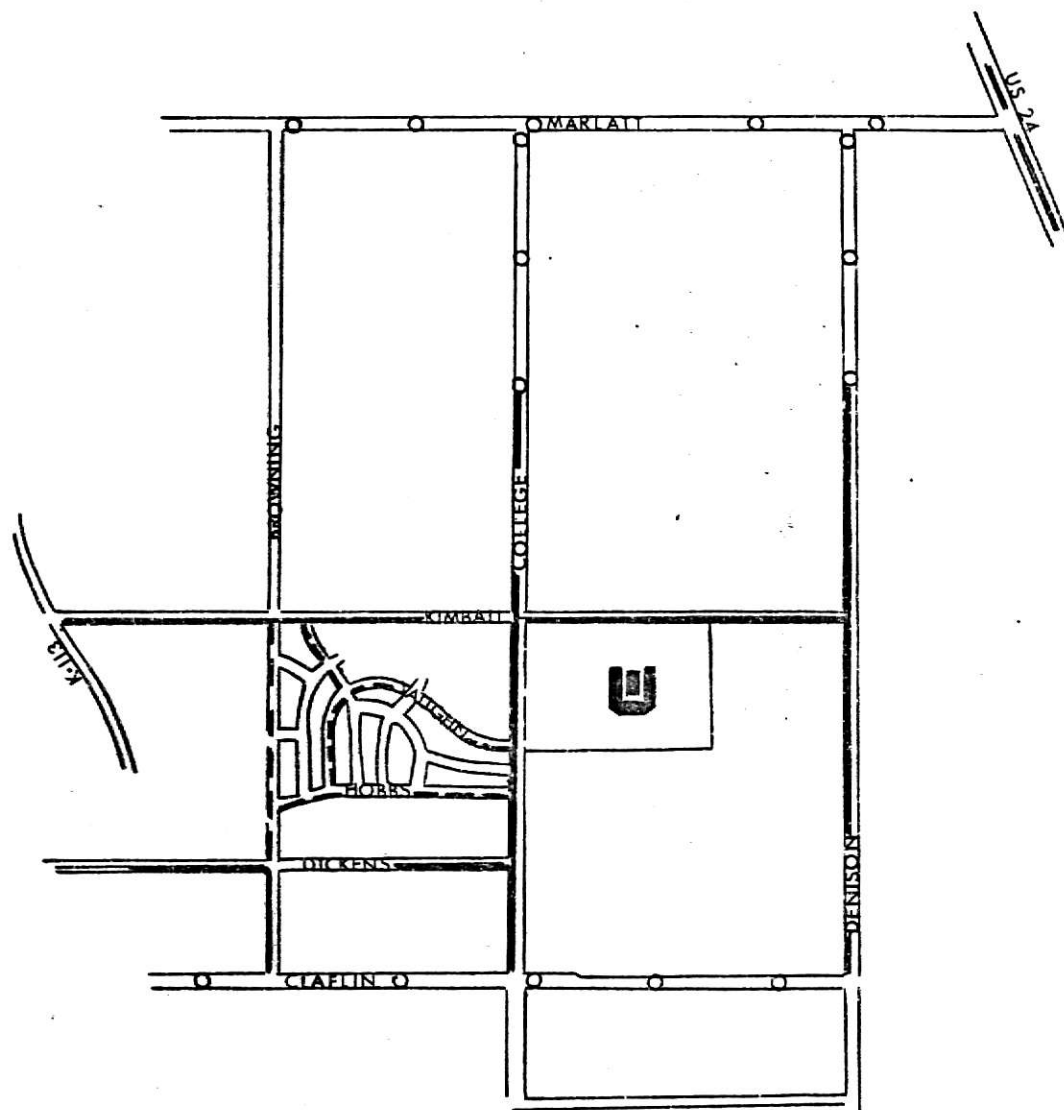
4. relation between directional signing and fan information
5. lane change for special reserved lot on Kimball Ave.
6. signs indicating shuttle bus points (see fig. 19)

To clarify this summary refer to figures 19 and 20.

Location of Direction Signs
(Figure 19)



Parking Control Signing (Figure 20)



Systems Elements of the Fan Information System

The following is a list of criteria developed which was applicable to the fan information system:

1. use and location of shuttle bus service
2. advise of need to arrive early
3. fan information providing most desirable routes to special reserved lot as well as to facility in general
4. information directed at encouraging car pooling
5. advising patrons and residents of traffic controls (one-ways and parking)
6. staggered price system

The above are the main criteria for the fan information system. The constraints of this system were the type of communicative devices available to generate this information. Generally speaking two types of communicative devices were available. These devices were:

1. Mailings by Athletic Department of Kansas State University
2. Mass media (more specifically newspapers, television, and radio)

The "Search for Alternatives" for this system was then, in large measure, a process of fitting the feedback criteria into the constraints posed by the communication devices that were available.

Search for Alternatives for the Fan Information System

The paramount objective of fan information was to encourage the use of buses. In developing alternatives in this system it is of interest to note the great acceptance of this service in connection with the Kansas City Chief's games¹. In large part the workability of this shuttle service can be attributed to fan information and fan enjoyment. A

major campaign to convince the fans that the shuttle service offered the easiest, most enjoyable mode by which to attend the games was undertaken. In conjunction with this, the transit company went to great lengths to make the buses attractive to the fans. This included banners, balloons, and other "gimmicks."

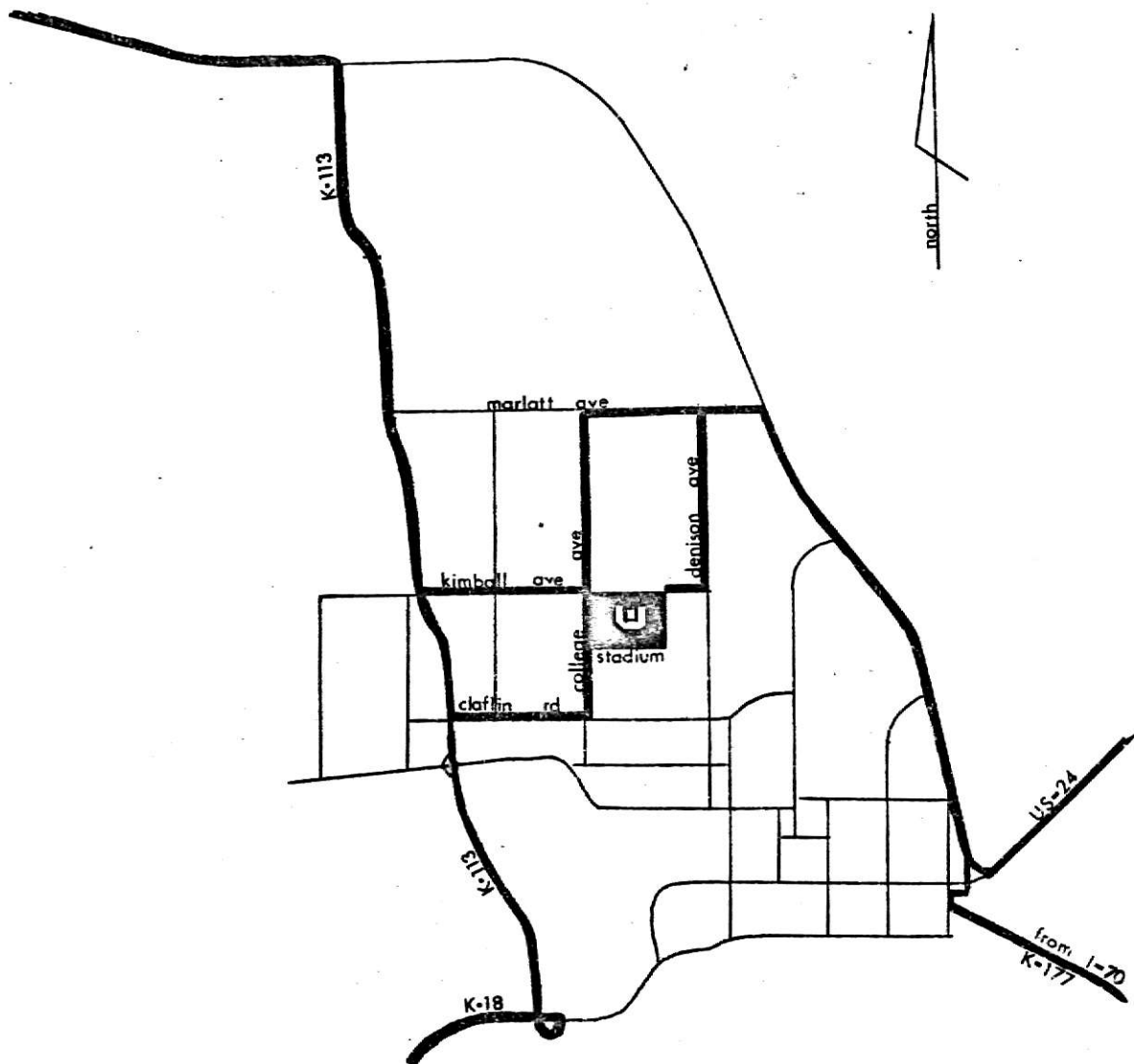
Various means of media exposure defining this service were available: (1) radio and television during sports broadcasts and (2) newspaper. (The local newspaper might well view this as a public service announcement.)

The need to arrive early was quite important. If the characteristic arrival demands were not altered from the pattern that existed at the old stadium, the traffic situation at the new stadium would present a difficult problem. Again a comparison with the Kansas City Chiefs can be drawn. Prior to the Chief's games, entertainment was provided and a campaign to stress the desirability of watching both this entertainment and the players warm-up period was undertaken. The suggestion of serving meals (barbecues) was raised in connection with the campaign for early arrivals. It was felt that this would help greatly in encouraging early arrivals.

The desirability of using the highway access routes has already been stressed to some extent to the public. While the over-use of the highways offer special problems, it would be quite surprising if this situation would develop. The best way of informing fans as to the most desirable access routes by way of a map. Figures 21 and 22 represent the type

of map that could be presented to the out-of-town and in-town fans, respectively. Figure 21 is a map that provided out-of-town fans a view of the major highways and the access streets most favorable to each of these routes. Figure 22 shows a map for local fans that depicts the most favorable route by districts according to average travel time.

Map to be Made Available to out-of-town Fans
(Figure 21)



Map to be Made Available to in-town Fans
(Figure 22)

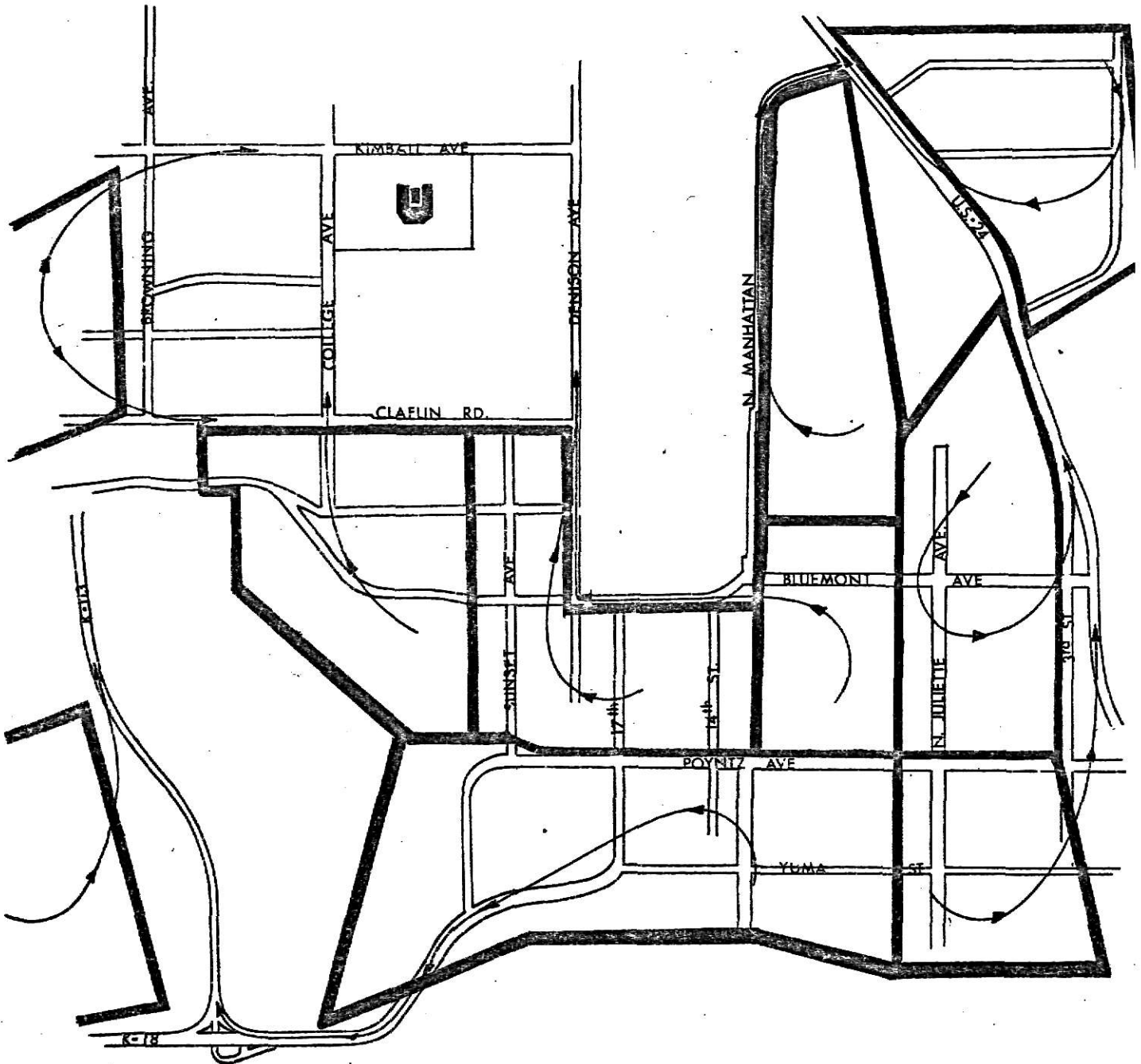
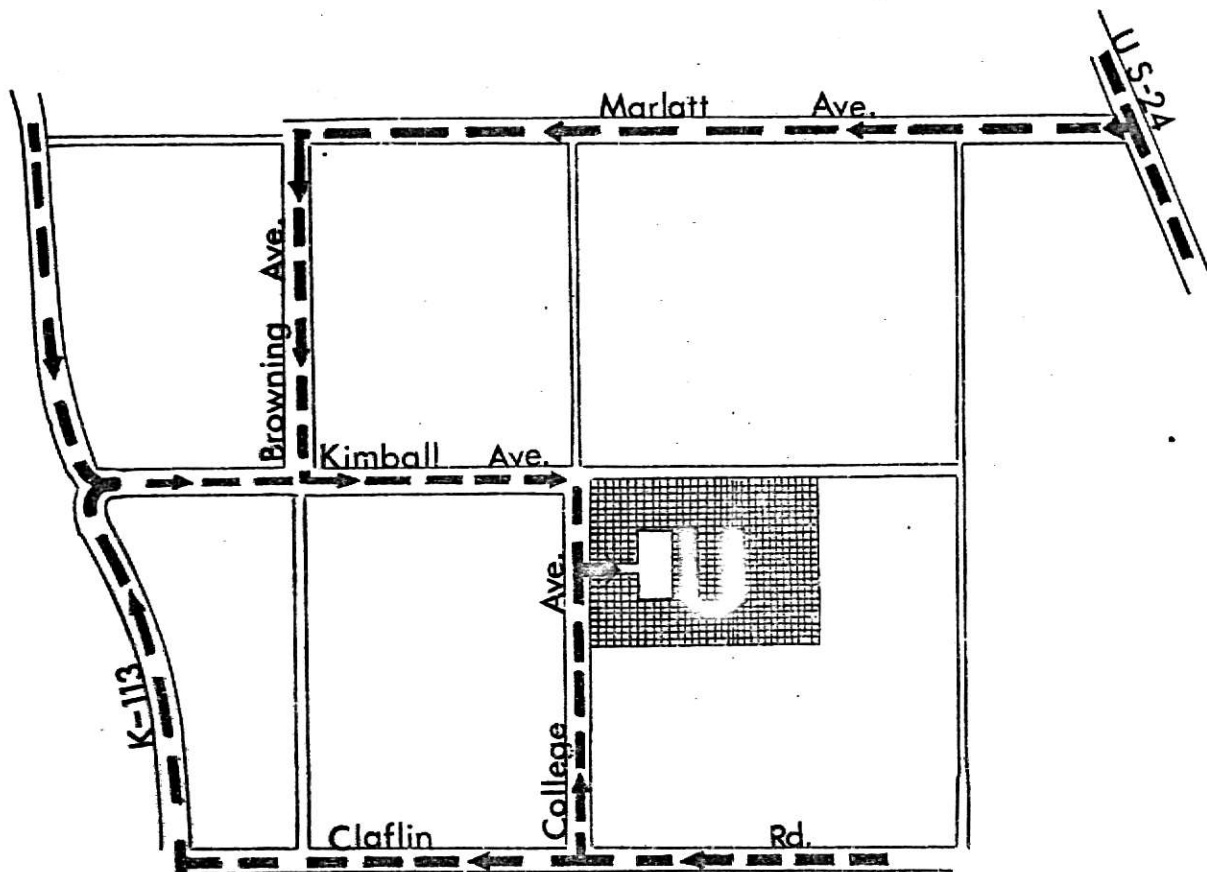


Figure 23 represents a map that should be made available to those that hold permits to the special reserved lot.

Map Showing Routes to Special Reserved Lot
(Figure 23)



The idea of car pooling was again something that was stressed in the Kansas City program that appeared equally attractive to the Kansas State situation. This was important from the standpoint of insuring a large occupancy per vehicle.

It was important to townspeople that they be given information concerning the traffic controls developed to insure good traffic flow at the stadium. This is important to both those planning a route to the stadium and those that live in the residential area surrounding the stadium.

In summary, the following recommendations were made.

1. Use of mass media (newspaper, radio & television) to stress the following:

- A. Use of buses
- B. Desirability of using highway routes
- 2. Literature to season ticket holders giving the following information:
 - A. Maps of routes
 - B. Map of route to special reserved lot
 - C. Written editorial describing pricing, and other information of importance
- 3. Local newspapers (Manhattan Mercury and K-State Collegian)
 - A. Local directional map developed on time basis
 - B. Student's lot location and access routes
 - C. Desirability of car-pooling and early arrivals
 - D. Desirability of the use of buses
- 4. Local newspapers to advise patrons and inhabitants of areas involved of the traffic control measures
- 5. Development of attractive shuttle bus as discussed in text
- 6. Development of some type of pre-game entertainment

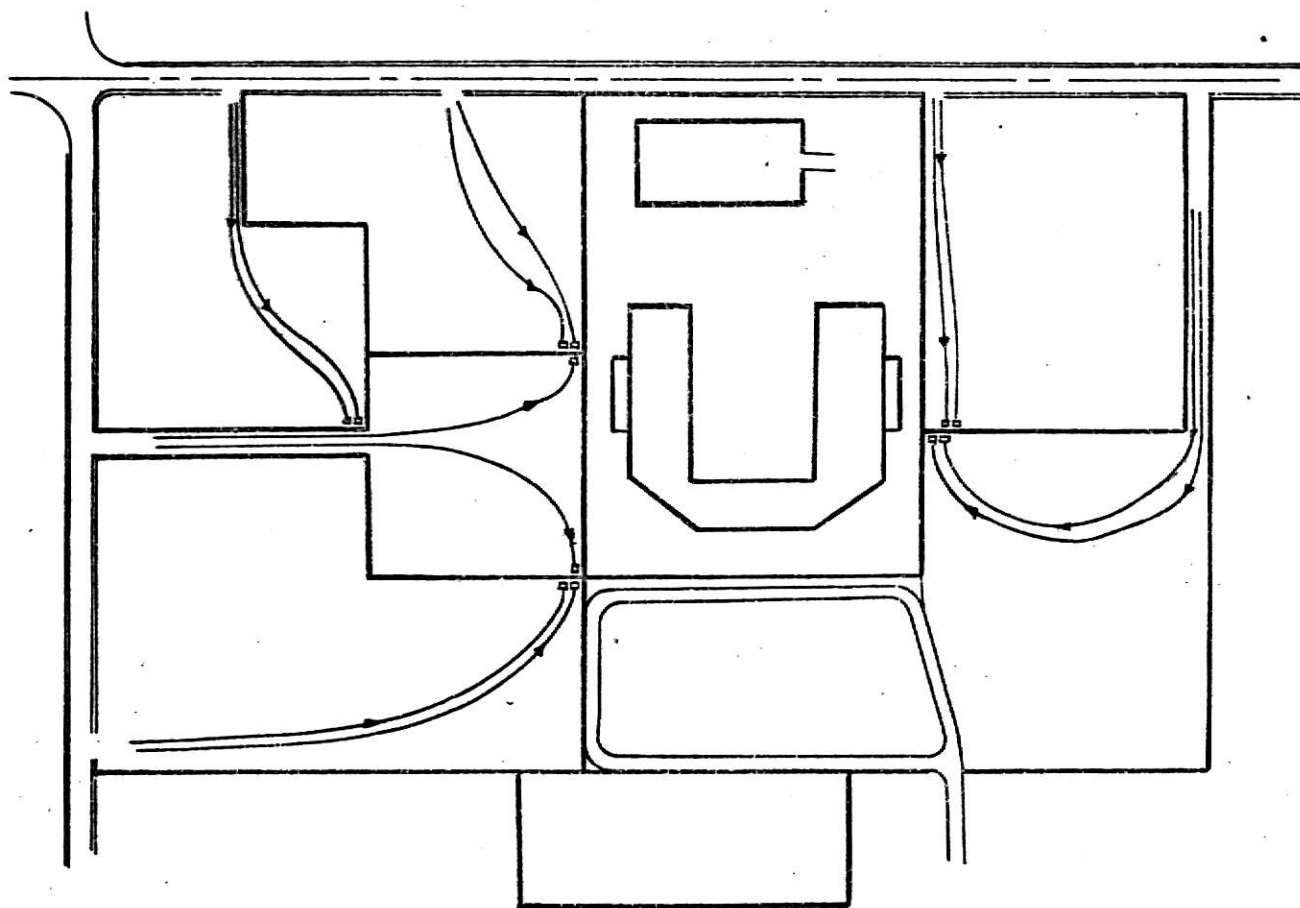
Systems Elements of the Interior Lot Management System

This was the final inquiry to be conducted. It should be noted that this subsystem was not constrained in terms of feedback from the analysis of the other subsystems. The one exception was that interior lot management should not be the limiting factor in the capacity of the system. The system had a limited capacity based on the physical constraints of the surface streets. It was therefore detrimental to the study objective to further limit this capacity by not providing an appropriate management system. Because of the lack of available information a firm statement could not be made concerning the volume the interior lot management system would have to handle without lot-handling becoming the limiting factor in the entire system.

Search for Alternatives for the Interior Lot Management System

The key word in the loading of the KSU Stadium lot was management. Adequate direction and guidance must be given to the entering vehicles. To accomplish this, each lot should be

Graphical Representation of the Stacking Operation
(Figure 24)



stacked in accordance with its own characteristics but based on the principle that the vehicles will more easily migrate toward the stadium than away from it.

The main theme of this management system was personnel. A sufficient number of people must be available in each lot to handle the high volume. The speed with which this team must operate is shown by an analysis of lot 1.

Lot 1 contains 1,335 spaces working with the 80% distribution of arrivals in 45 minute period described earlier, we see that an expected hourly volume of 1,425 veh/hr is possible. This figure means that the management team must handle the vehicles on the average of 2.5 seconds each. This is a very rapid processing but can be handled with sufficient manpower.

In accordance with this need the following personnel were recommended:

1. Traffic Manager -- The traffic manager should position himself outside the lot and help direct and control traffic into the lot. Another duty is helping to relieve the formation of queues. (one per lot)
2. Operators -- The lot operator's duties are to collect money and make change. (four per lot)
3. Flaggers -- The duty of the flaggers is to direct the flow of traffic to the stacking operation. There should be a head flagger who is responsible for the separation of traffic when stage changes are undertaken and who is also in radio communication with the system controller. (two per lot)
4. Stackers -- The stackers are necessary in order to insure that cars are parked correctly. (four per lot)

The operation of the special reserved lot and the bus lot are somewhat different than the above. They are given the

following personnel recommendations.

Special Reserved Lot --- This lot should have two traffic managers located outside the lot to insure that vehicles not allowed to enter this lot are rejected. The special Reserved Lot should also have two flaggers and four stackers. (eight people in total)

Bus Lot --- Entrance to the special bus lot must be denied to passenger vehicles. In order to accomplish this, campus police should act as lot managers. The remainder of the personnel required for the bus lot will depend on its usage. If many charter and shuttle buses are anticipated stackers and flaggers should be provided though the number will vary with demand. (With maximum usage personnel needed would be; two police and six interior lot personnel)

Using this approach sixty-nine employees and two campus police would be needed to operate the lot.

To help the management control the operation of the lot, certain physical items are necessary.

1. Physical barriers to outline interior lot streets and individual lot outlines: (This barrier can be any of a number of possible alternatives depending on the material available. These barriers could be either cable and railroad ties or fencing. The combined length of the barriers needed to conform to the plans is 3,900 feet.)
2. Delineation of the parking zones: (This is a must in order to approach maximum usage of the lot spaces available. The most workable idea is to stripe the medial strips with paint.)

The delineation of the parking zones will demand the retainment of a surveyor to lay the lot out for the striping crews.

Interior lot management during the unloading process presented a problem. It was not possible to unload the lot as it was loaded, quite understandably. This precluded the need for a large personnel force during this period. There did seem to be a definite need for a small force to remain in the

lot so that maximum use of the exit facilities could be gained. To accomplish this task, the head flagger and one other man should remain. Their principal duties would be to insure two lanes exiting are formed and to report on the unloading progress to the controller.

In summary the following recommendations were made:

1. A force of 69 employees to be used as outlined in text.
2. Physical barriers to outline interior lots.
3. Delineation of parking zones.
4. Stacking of the vehicles will be head to tail.
5. Stacking is to be accomplished in three progressive stages continually away from the most desirable location.
6. Free across lot movement will be allowed only as directed by management personnel.
7. Location of lot managers outside the lot entrance to help facilitate traffic flow on surface streets.

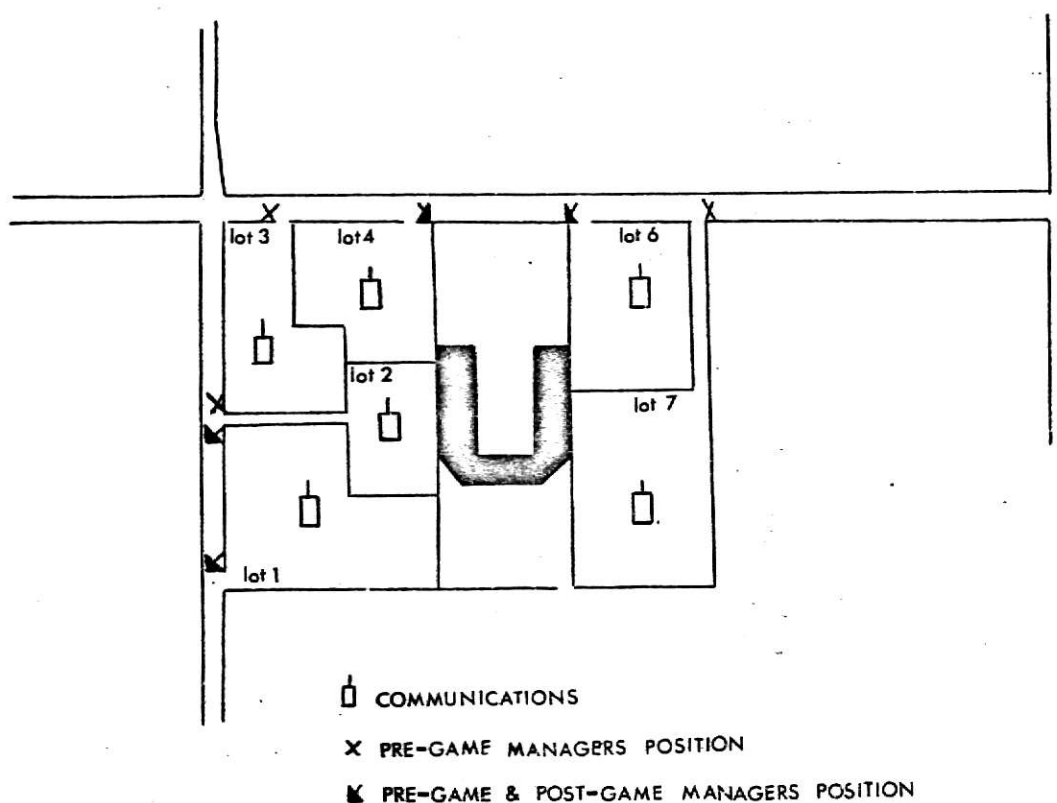
(Note: See figures 24, 25, and 26, to help clarify recommendations)

Feedback into the System Environment

As mentioned earlier the environment for the transportation system surrounding the new stadium was divided into two classifications: social and physical. Within these classifications were the various recommendations that were made. The recommendations that caused feedback and questions in the systems environment were:

1. What is the effect of proposed one ways on the community traffic system?
2. What is the effect of permanent signs on the urban landscape?
3. What is the attitude of the public toward parking price scale?
4. What is the attitude of students toward their restricted use of the parking facility?

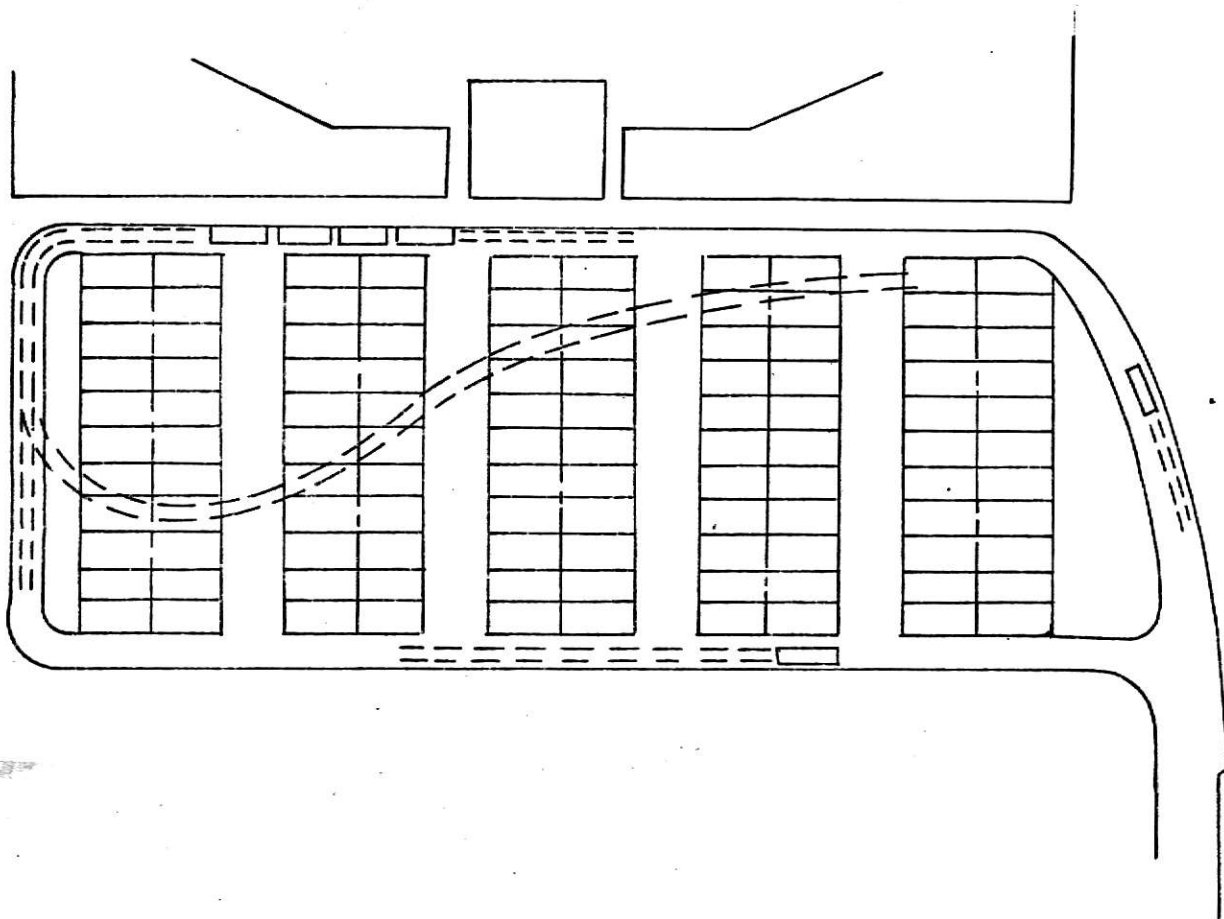
Positioning of lot Managers
and Communications
(Figure 25)



It was felt that the effect of the proposed one-ways on the community traffic system would be minimal. The area that involved one-ways did not ordinarily carry a high volume of traffic. Therefore the streets not affected by the one-ways would serve as adequate egress routes for the residential areas involved without becoming overloaded.

Many of the signs proposed were warranted without the stress of the special event traffic generated by the stadium. These signs, it was clear, were best made permanent. Other signs applying directly to the stadium generated traffic

Graphical Representation of Bus Unloading
and Stacking Operation
(Figure 26)



should not be made permanent. They should be placed prior to each game. The directional signs should be placed for the season of use only. Following the conclusion of the football season they should be removed. The directional signs on the highways should be permanent in construction.

The attitude of the public toward the pricing scheme was not anticipated to be critical. It had a simple logic that

offered a means of reducing the cost per vehicle at the parking facility.

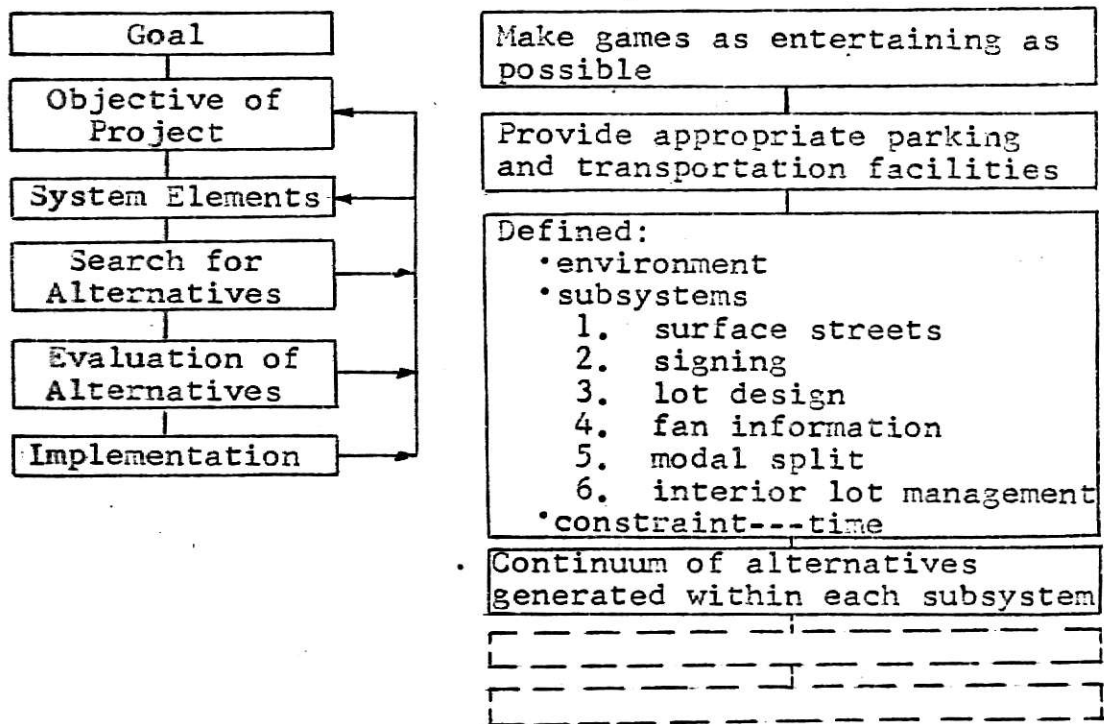
The attitude of the students toward the proposal directed at limiting their parking spaces was of much concern in this study. The restriction proposed however did not severely limit the number of student vehicles that could park at the stadium. The number of student parking spaces was determined on the basis of both students as a percentage of a capacity crowd and by the vehicle-occupancy ratio desired. It must be remembered that a proposal to make buses available to the University dorm complex was also made.

Finally in relation to the fact that students' tuition was used to underwrite the bonds for the new stadium, it can be said that many of the non-students attending the games are alumni who had paid student fees which were used for similar purposes and that this does not negate the need for students parking restrictions.

EVALUATION OF ALTERNATIVES

To this point the system process has been completed through step 4 "generation of system alternatives" in the process. This is shown schematically in figure 27.

Diagram of Process through the
"Search for Alternatives" Step
(Figure 27)



The recommendations that have been made under the title of individual subsystems are integrated by the fact that feedback information was used in the various inquiries. The evaluation of alternatives is then a decision making operation. Realistically it is a matter of points of view as applied to the manner in which the alternatives reflect the accomplishment

of the goal. Or possibly it is a matter of altering the objective because the alternatives generated are not attractive to the decision makers. If the latter is the case then it generally is necessary to reenter the systems approach as outlined and generate a new set of alternatives. In this case (the subsystems having been generated independently) this was not necessary.

In this study the alternative representing the system providing the best possible reflection of the study objective was deemed inoperable by the decision makers involved. In accordance with the system process this required a redefining of the study objective. The new objective could be stated as follows; "Provide a passenger vehicle facility to handle the KSU Stadium lot traffic." In accordance with this objective the following recommendations were accepted:

1. College Ave. between Claflin Rd. and lot entrance 2 be made one-way north prior to game (affective at 12:30 p.m. or when traffic warrants such action)
2. Denison Ave. between Claflin Rd. and Kimball Ave. be made one-way north prior to the game (affective at 12:30 p.m. or when traffic warrants such action)
3. Post-game one-ways
 - A. College Ave. between Claflin Rd. and entrance 1 one-way south
 - B. Kimball Ave. between entrance 4 and K-113 one-way west
 - C. College Ave. between entrance 2 and Marlatt Ave. one-way north
 - D. Denison Ave. between Claflin Rd. and Kimball Ave. one-way south
 - E. Denison Ave. between Marlatt Ave. and Kimball Ave. one-way north
4. Police controlled intersection pre-game
 - A. Kimball Ave. and Browning Ave. -- communications
 - B. Dickens Ave. and Browning Ave.
 - C. Claflin Rd. and Browning Ave.

- D. Claflin Rd. and College Ave.
- E. Dickens Ave. and College Ave. -- communications
- F. Kimball Ave. and College Ave.
- G. Marlatt Ave. and College Ave.
- H. Marlatt Ave. and Denison Ave. -- communications
- I. Kimball Ave. and Denison Ave.
- J. Jardine Dr. and Denison Ave.
- K. Claflin Rd. and Denison Ave.
- 5. Police controlled intersections post-game
(same as above except)
 - A. Dickens Ave. and Browning Ave.
 - B. Dickens Ave. and College Ave.
(with the addition of)
 - A. Kimball Ave. and K-113
 - B. Marlatt Ave. and US 24
- 6. Reservation of exclusive emergency lane on College Ave. from Vaughn Dr. to hospital entrance
- 7. Lot 2 (special reserved lot) should be reduced to 800 spaces with the other 350 spaces placed in lot 4
- 8. Full parking restrictions on the following routes
 - A. Kimball Ave. from K-113 to Denison Ave.
 - B. Dickens Ave. from K-113 to College Ave.
 - C. Claflin Rd. from K-113 to Denison Ave.
 - D. College Ave. from Claflin Rd. to Marlatt Ave.
 - E. Denison Ave. from Claflin Rd. to Marlatt Ave.
 - F. Browning Ave. from Dickens Ave. to Claflin Ave.
- 9. One side parking restriction on the following routes
 - A. Browning Ave. -west side- Dickens Ave. to Kimball Ave.
 - B. Hobbs Ave. -south side- Browning Ave. to College Ave.
 - C. Vaughn Dr. -wouth side- Hobbs Ave. to College Ave.
 - D. Kenmar Dr. -west side- Vaughn Dr. to Kimball Ave.
- 10. Directional signs on highways
- 11. Directional signs on city and county streets
- 12. Fan information providing most desirable routes to the special reserved lot as well as the facility in general in coordination with route signing
- 13. Advise of need to arrive early
- 14. Advising patrons and residents of traffic controls (one-ways and parking restrictions)
- 15. Physical barriers to outline interior lots

IMPLEMENTATION

To help implement this system a control post was established. This control post was in radio contact with both the police and the interior lot management team. An observation plane was also available for use by control personnel.

The recommendations were accepted with the plan that traffic flow at the first game would be studied and further recommendations would be made based on the findings from this study. In terms of the systems process this was in effect a feedback from the "implementation" step to the "systems elements" step. The inquiry into the remaining steps would then be undertaken.

The actual implementations of the recommendations was carried out with a great deal of cooperation among the University, state, county, and city. All of the proposals were activated with a great deal of enthusiasm and efficiency.

CONCLUSION

One of the criteria for accepting the alternative that was implemented was that the transportation system would be studied and changes made to handle these problems. This study plan called for five minute volume counts and thirty minute vehicular occupancy at each gate. In addition to this, key intersections were photographed every five minutes by a circling observation plane.

The attendance at the first game was approximately 22,000. The distribution of arrivals by modes was as follows:

1. passenger vehicles	15,600
2. pedestrian	4,600
3. shuttle buses	300
4. special buses	800
5. drop-off arrivals	400
Total	21,400

The occupancy it was hoped, would approach that found at the Kansas City Chiefs games (3.5 occ/veh). This was not the case. The occupancy was strongly variable between the student and non-student classification. The average student occupancy was found to be 3.37 occ/veh. The average non-student occupancy was found to be 3.16 occ/veh. The overall average was 3.23 occ/veh.

The average entrance volume based on the highest six five-minute counts for all six lots was found to be 508 veh/hr. The range was 624 veh/hr to 402 veh/hr. The average exit

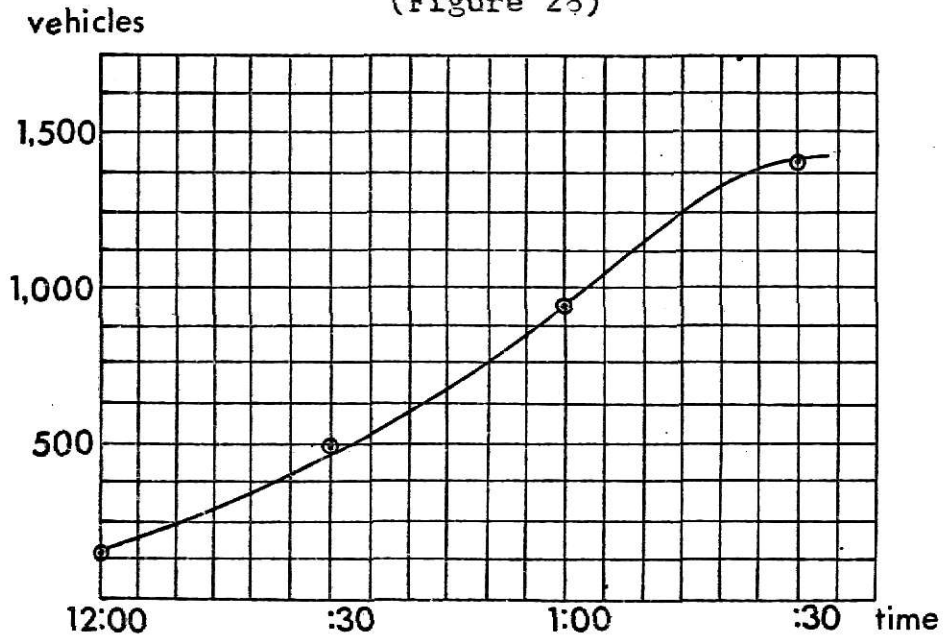
volume based on the four highest five minutes was found to be 1,267 veh/hr. The range was 923 veh/hr to 1,945 veh/hr.

The arrival periods were difficult to analyze. The limiting capacity of the streets and lot entrances caused the formation of sizeable queues. It was possible from the counts at the lot entrances and the increase in the queue length to begin to understand the true arrival demand for the facility. First the demand was on the streets east of the stadium. Nearly 1/2 hour later the demand was of equal intensity from all directions. The early demand corresponded to the general direction students would travel. This seemed to indicate the early student arrivals predicted in this study. Declarative statements on this and other assumptions made in the course of this study are of this study are difficult to prove or disprove because of the development of queues which had a clouding effect on the data collected.

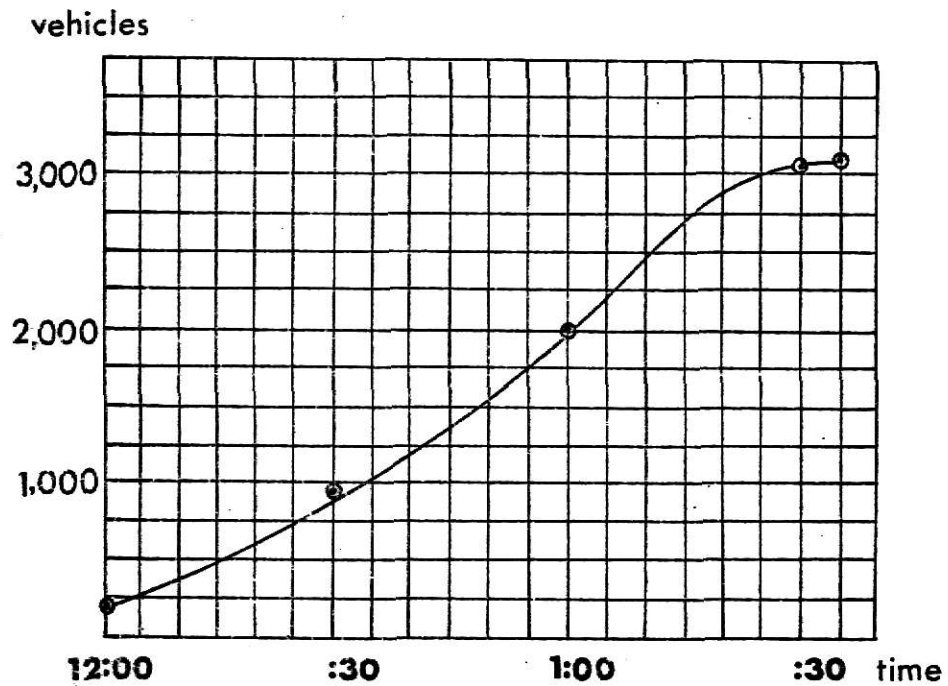
The following graphs demonstrate the cumulative arrival demand for students, non-students, and combined demand which takes into account the vehicles in queue.

(Note: The nearly straight line demand curve reflects the result of the queue buildup.)

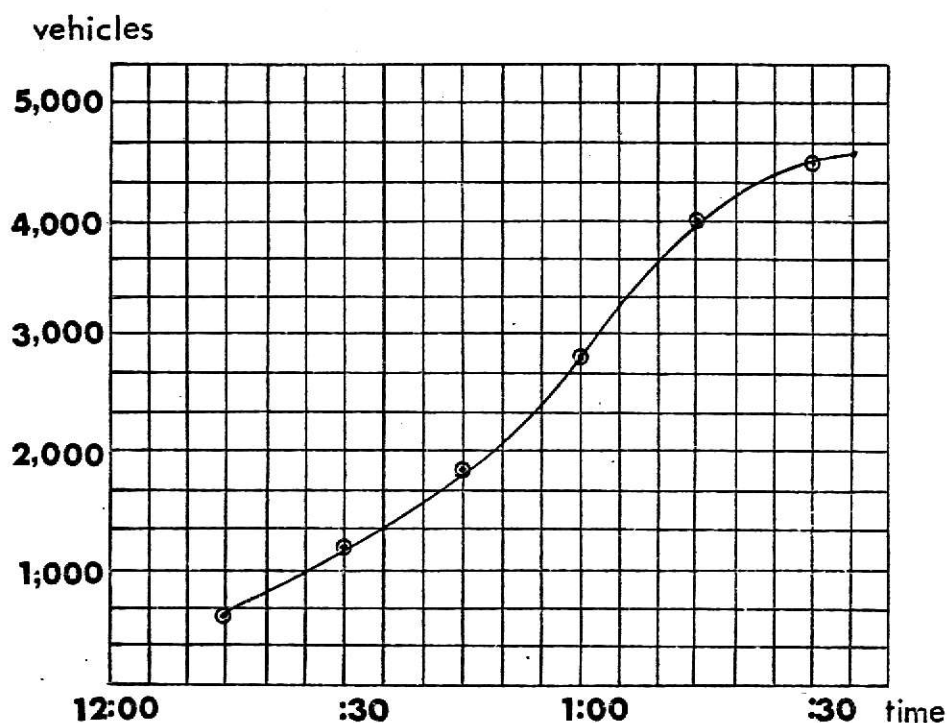
Graph of Cumulative Student Arrivals Taken
from the Lot Entrance Counts
(Figure 28)



Graph of Cumulative Non-Student Arrivals
Taken from the Lot Entrance Counts
(Figure 29)



Graph of Cumulative Combined Arrivals taken from
the Lot Entrance Counts and Queue Lengths .
(Figure 30)



The data collected pointed up several problem areas. Of first importance was the use of buses. The stadium lot contained 4,500 vehicles with a capacity of handling 1,350 more vehicles. The surface street parking was utilized to some extent. Nearly 100 of the available 500 spaces were used. We had then 1,650 parking spaces that could be used with a greater crowd. With the above mentioned occupancy (3.23 occ/veh.) these extra spaces would generate 5,350 more patrons. If it can be assumed that the other modes will remain rather constant it is seen that with a crowd of 26,750 the lot would be filled and 6,600 vehicles would be using the stadium system. With a capacity crowd of 35,000 nearly 2,560

vehicles would demand access to the stadium without finding parking spaces. The point of this numerical exercise is to indicate the strong need for a bus service. Even operating under the redefined objective it is seen that good traffic movement can not be maintained without removing some passenger vehicles from the system. The best way to do this is by the promotion of the use of buses.

The low lot entrance rates plus the photos of the queue formation indicated that the manner of taking money and giving tickets was a major bottleneck in the system. It was important that this bottleneck be eliminated.

The final area of difficulty was the lack of full usage of the available facility. For instance Denison Ave. from Claflin Rd. to Kimball Ave. was not made one-way. Kimball Ave. at the intersection with College Ave. is five lanes wide yet it carried only one lane of traffic at the peak period. The result was a queue formation of 150 vehicles between College Ave. and K-113 along Kimball Ave.

This new information forms a new and sounder basis for developing alternatives. They in large measure reinforce the original recommendation.

In summary the following recommendations are made.

1. Strong emphasis on the use of buses. This includes the development of an exclusive routing system for their use.
2. Foregoing the use of tickets at lot entrances.
3. Better utilization of facilities, primarily a management problem.

SUMMARY

It is believed the foregoing study is a good although admittedly simplified example of the systems approach. However the simple principles given herein form a sound basis for approaching a more complex problem.

The importance of formalizing a system cannot be over-emphasized. In this example some of the feedback of the subsystems applied to the inquiry of other subsystems could have been carried out without a formalized process. While this is true to some extent in these examples it is not the case in studies of larger magnitude.

One of the principal reasons that the systems approach is gaining favor is that it is a natural means by which to develop designs directed at realizing planning goals and humanistic ideals. The idea of social impact as a subsystem is not often considered along with the other subsystems. It is possible, as was done in this study, to initiate the entire inquiry with an objective of design that describes the social impact of the design.

In a study of this sort it is rather hard to imagine a really "good" study that does not consider the needs of the people since it is concerned with the movement of people.

Growing out of the concept of systems approach is the idea of a systems design team. The systems design team represents possibly the first attempt ever to provide a truly

comprehensive design. The systems design team is a group of individuals with different backgrounds each lending his expertise to the design process.

The study just reviewed did not have a systems design team. It is important to note however, that an important part of the systems process is the awareness on the part of the decision makers involved as to the logic of the proposals. In this study it was important because of the large number of governmental units involved, state, county, city, and university that several meetings be held to explain the process, examine alternatives to subsystems, and make decisions.

In effect these meetings acted as a systems team. Each of the various representatives served as a perspective from the point of view of their constituency. These points of view served to broaden the scope of the design.

The ultimate guiding criteria for this study and indeed the systems approach itself is summed quite well by the following observation by Bertrand Russell.⁸

"In the welter of conflicting fanaticisms, one of the few unifying forces is scientific truthfulness, by which I mean the habit of basing our beliefs upon observations and inferences as impersonal, and as much divested of local and temperamental bias, as is possible for human beings. To have insisted upon the introduction of this virtue into philosophy, and to have invented a powerful method by which it can be rendered fruitful, are the chief merits of the philosophical school of which I am a member. The habit of

careful veracity acquired in the practice of this philosophical method can be extended to the whole sphere of human activity, producing, wherever it exists, a lessening of fanaticism with an increasing capacity of sympathy and mutual understanding. In abandoning a part of its dogmatic pretensions, philosophy does not cease to suggest and inspire a way of life."

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A SYSTEMS APPROACH TO THE STUDY OF THE TRANSPORTATION
FACILITIES SERVING KSU STADIUM

by

WILLIAM LEE SMITH

B. S., Kansas State University, 1968

AN ABSTRACT OF A MASTER'S REPORT

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requirement for the degree

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1969

It was the purpose of this work to examine the transportation facilities serving the KSU Football Stadium. This examination was directed toward providing a comprehensive transportation system to serve the stadium.

A secondary purpose of this work was to define and provide an example of the "systems approach" by which a design problem could be undertaken.

The systems approach used in this study was expanded from a problem solving process developed by the philosopher John Dewey.

It was recognized that the activities associated with KSU Stadium could be classified as special events. Special events, it was found, could take many forms; they could be political rallies, religious gatherings, various forms of entertainment. What characterized the gatherings was that they were infrequent in nature. This infrequency, plus the broad base of appeal from which they were able to draw, created massive gatherings of people. This gathering of people resulted in a crush on the transportation system surrounding the facility hosting the special event. Because of the complexity of this problem it was hoped that by using the systems process in this inquiry all variables relevant to the project under study would be examined.

The objective of the inquiry into the KSU Stadium transportation system was to develop a workable system that would provide appropriate parking and transportation facilities

Influencing the final development of the stadium system were six interlocking elements. The elements were:

1. Surface streets surrounding the stadium.
2. Modal split (i.e. the method of transportation chosen by stadium patrons).
3. The physical layout of the stadium parking lots.
4. Use of directional and traffic control signing.
5. Type and amount of information to be made available to public.
6. The management of interior lot traffic flow.

The development of these elements was constrained by the lack of time available to implement certain alternatives. Another constraining influence was the physical and social environment in which the system was to operate. Working within these elements recommendations as to the optimum course of action were made.

A survey of the more important variables was conducted during the first game. The information gathered in this survey was in turn used to re-evaluate the recommendations that were made.