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A STUDY TO DETERMINE  
THE OPTIMAL METHOD OF  
SCHEDULING RADIOLOGICAL EXAMINATIONS DURING  
THE ELECTRICAL-MECHANICAL UPGRADE PROJECT  
AT MUNSON ARMY COMMUNITY HOSPITAL

A Graduate Research Project  
Submitted to the Faculty of  
Baylor University

In Partial Fulfillment of the  
Requirements for the Degree

of

Master of Health Administration

by

Captain Daniel D. Remund, MS

June 1986

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## I. INTRODUCTION

### CONDITIONS WHICH PROMPTED THE STUDY

The demand for radiological examinations at Munson Army Community Hospital (MACH), Fort Leavenworth, Kansas, routinely exceeds the capacity of the Radiology Department because of an insufficient number of functional examination rooms. Patients and physicians complain about excessive waiting times for x-rays. Large backlogs of requests for fluoroscopic and other special radiological examinations are common. Scheduled appointments for these examinations are often booked for more than a month in advance. A new scheduling policy was initiated in October 1985 in an effort to hold the backlog of examination requests to an acceptable level. Physicians requesting examinations are to designate the maximum time the patient can wait for an appointment. If an appointment is not available within that time period, the patient is automatically sent to another hospital--usually the Veterans Administration Medical Center (VAMC) in Leavenworth or the Kansas University Medical Center (KUMC) in Kansas City--to undergo the examination. MACH pays for these examinations with Supplemental Care funds. - RFA

When the proposal for this study was initially developed in May 1985, MACH had two functional examination rooms equipped with General Electric and Siemens x-ray machines. A Phillips x-ray machine was on hand for placement in a third room which



was to have been completed by June 1985.

MACH expected the addition of a third examination room to reduce patient waiting time, the backlog of examination requests and the expenditure of Supplemental Care funds for examinations at other facilities. However, the benefits of the Radiology Department's expanded capacity were to be short-lived because of the Electrical-Mechanical Upgrade (EMU) project at MACH.

Renovation of the Radiology Department under the EMU project is scheduled to begin in August 1986. The examination rooms are to be closed for renovation, one at a time, for a period of three months each. As a result, the Radiology Department was expected to again function with only two examination rooms from August 1986 to May 1987.

MACH never attained three functional examination rooms. Numerous problems, including an inadequate site preparation survey and the bankruptcy of a contractor, delayed the construction of the Phillips room. To make matters worse, the Siemens machine broke down in October 1985, leaving MACH with only the General Electric machine functional. The Siemens machine had a history of frequent mechanical failures, and repairs to make it fully operational would have cost \$40,000. Since a replacement for the Siemens machine was already programmed in the Medical Care Support Equipment (MEDCA: E) program, it was decided not to repair the Siemens machine and to expedite procurement of a replacement machine. Delivery and installation of a Picker x-ray machine to replace the Siemens

machine was expected by March 1986.

Problems with room construction and installation of the Phillips machine and delays in the procurement and installation of the Picker machine have continued since October 1985. The Phillips machine is now expected to be operational in June 1986. The Picker machine is expected to be operational by November 1986.

The Radiology Department has functioned with only the General Electric x-ray machine since October 1985. Although the Phillips room will be operational in June, it will be closed for the EMU renovation project in August, so the Radiology Department will again function with only the General Electric machine during the first three months of the project. The Phillips and Picker rooms will be operational during the second three-month period, and the Phillips and General Electric rooms will be operational during the final three months of the project.

During the EMU project, the backlog of examination requests will still be controlled by the policy that automatically sends patients to other hospitals when an appointment is not available within the time frame specified by the physician requesting the examination. MACH wants to minimize the expenditure of Supplemental Care funds for radiological examinations by maximizing the number of examinations done in-house. However, the hospital does not want to do so many examinations in-house that the patient waiting times are excessive. The Radiology

Department needs an examination scheduling method that minimizes expenditures on examinations done at other hospitals and adequately controls waiting times for examinations done at MACH.

#### PROBLEM STATEMENT

To determine the optimal method of scheduling radiological examinations during the electrical-mechanical upgrade (EMU) project at Munson Army Community Hospital, Fort Leavenworth, Kansas.

#### OBJECTIVES

1. Analyze the current method of scheduling radiological examinations.
2. Quantify parameters that describe the current operation of the Radiology Department.
3. Estimate the radiological workload that is expected during the EMU project.
4. Identify the constraints that are expected to affect the service capabilities and examination scheduling methods of the Radiology Department during the EMU project.
5. Based on a literature search and consideration of the information obtained above, identify alternate examination scheduling methods.
6. Estimate the longest average waiting time that is expected during the EMU for patients arriving within a one-hour

period, given the alternate scheduling method.

7. Given the constraints associated with the alternate scheduling methods, use linear programming to determine the number and mix of examinations to be scheduled at MACH that will minimize the expenditure of Supplemental Care funds for examinations to be performed at other hospitals.

#### CRITERIA

1. The optimal scheduling method will result in a longest expected average waiting time for patients arriving within a one hour period that is less than or equal to the maximum acceptable average patient waiting time set by the Chief of the Radiology Department. This criterion takes precedence over subsequent criteria.

2. The optimal scheduling method will schedule the number and mix of examinations to be done at MACH that will result in the lowest projected expenditure of Supplemental Care funds for examinations to be performed at other hospitals as determined by linear programming.

3. If projections indicate that more than one alternate scheduling method will accommodate the entire projected examination workload, the optimal scheduling method is that method which, in the opinion of the Chief of Radiology, is the most convenient for the Radiology Department to utilize.

## ASSUMPTIONS

1. Staffing levels and the productivity of personnel in the Radiology Department will not change significantly from their current levels during the EMU project.

2. There will be no major changes in the radiological equipment utilized.

3. Data concerning the time required to perform a given procedure with the General Electric machine can be applied to the Picker and Phillips machines. This assumption is necessary because the General Electric machine will be the only machine in operation during the study period.

4. Unless it is altered by the alternate scheduling method, the hourly pattern of patient arrivals in the Radiology Department will be the same during the EMU project as that observed in the study period.

## LIMITATIONS

1. The study is limited to investigating changes in the method of scheduling radiological examinations. The study will not address measures to increase the productivity of the individuals in the radiology department.

2. For a given method of scheduling examinations, the estimation of the expected average waiting times during the EMU (Objective 6) would ideally be determined with a queuing model

or computer simulation.<sup>1</sup> The complexity of a queuing model that would be applicable to this study precludes the use of the model by the student. Computer simulation techniques will not be used in this study, because the student lacks the expertise, time and computer support necessary to develop a computer simulation program.

#### LITERATURE REVIEW

A review of the literature revealed a number of management studies and research efforts related to scheduling of examinations in radiology departments. Most of the articles that concentrated directly on scheduling methods identified staffing concerns as the primary impetus for the study.<sup>2</sup> Concern for patient waiting time, facility constraints and the impact of patient flow problems on the nursing staff are other issues that prompted work in this area.<sup>3</sup>

Studies to measure the productivity of a radiology department because of high personnel costs, complaints about waiting time and requests to expand facilities all touched on the need for a scheduling system to control the flow of patients.<sup>4</sup> Articles devoted to the analysis and control of patient waiting time also covered some aspects of scheduling methods.<sup>5</sup> One author's description of the objective of a patient scheduling system illustrates why scheduling issues are frequently addressed in radiology management studies: "An

adequate patient scheduling system in a radiology department should minimize patient waiting time while maximizing use of personnel, equipment, and facilities."<sup>6</sup>

Radiology departments suffer from a chronic problem of uneven workload during the day. Morning hours are busy, but equipment and personnel are often idle later in the day. Scheduling systems are implemented in an attempt to even out the flow of patients. Some authors insist that all examinations, except emergencies, should be scheduled.<sup>7</sup> A computer system can greatly enhance efforts to schedule all examinations.<sup>8</sup> Others cite large numbers of outpatient examinations and inadequate communication systems as barriers to scheduling more than a small portion of the examinations.<sup>9</sup>

The literature review yielded examples of industrial engineering and operations research techniques employed in the analysis of radiology departments. Work sampling, time records (logs), standard times and time studies are work measurement techniques used to determine the length of time required to perform examinations.<sup>10</sup> Data on patient waiting time have been analyzed with simulation techniques and regression analysis.<sup>11</sup> An article that was located after the proposal for this study had been written discussed the use of linear programming to maximize the contribution margin of an Ambulatory Diagnostic Center through case mix management.<sup>12</sup>

Although some articles referred to queuing theory, the actual use of queuing theory models and techniques to analyze

service capacity and patient waiting times was conspicuously absent from the literature. Queuing theory is used to study the functions of service systems.<sup>13</sup> Queuing models quantify such aspects of a service system as: (1) the average time a customer waits for service, (2) the average number of customers waiting in line, and (3) the probability that the service facility will be idle.<sup>14</sup> A problem with queuing theory is that the models become very complex when customer arrival patterns, queue discipline, service times and service configurations do not satisfy certain conditions.<sup>15</sup> This might explain why applications of queuing models to radiology departments were not found in the literature. Simulation techniques may be useful when the complexity of the service system precludes the use of queuing theory models.<sup>16</sup>

#### RESEARCH METHODOLOGY

OBJECTIVE 1: The current method of scheduling radiological examinations will be analyzed by examining documents such as Standing Operating Procedures and NRC Regulations, and by observing the operation of the department. The analysis will determine the following:

1. Examinations that can be performed in each examination room
2. Examination rooms and time periods that are normally reserved for certain examinations



3. Types of patients (inpatient versus outpatient) and/or examinations that are normally scheduled by specific appointment times

4. Number of minutes each room is scheduled to be available for service on a daily basis

5. Number of minutes historically allotted in the schedule for various procedures

**OBJECTIVE 2:** An analysis of the Radiology Department operation will be conducted using the Radiology Daily Register (MACH Form 252), the Radiology Daily Procedure Schedule (MACH Form 220), and the Patient Control Card (MACH Form 51). Examples of these forms are provided as Appendixes A-C. In addition to the information normally recorded on the above forms, the following data will be recorded for each examination:

1. Time patient arrived at the radiology department
2. Time patient entered examination room
3. Time patient departed examination room

The patient arrival time will be recorded on the Radiology Daily Register by the receptionist. The times the patient entered and departed the examination room will be recorded on the Patient Control Cards by the radiology technicians. Data will be collected over a four-week period.

The data collected will allow the calculation or description of the following parameters concerning the operation of the department:

1. The average service time for each type of examination
2. The distribution of scheduled and unscheduled patient arrivals for each hour of the day
3. The average patient waiting time experienced by patients arriving during each hour of the day
4. Examination room utilization rates (in minutes used per day)
5. The number of radiological examinations requested by the various clinics

OBJECTIVE 3: The radiological workload expected during the ENU project will be estimated based on historical data and any expected major changes in the demand for radiological examinations. Workload data will be obtained from the Radiology Department's monthly workload report and the Patient Administration Division's monthly report on examinations ordered under Supplemental Care funds. The estimate will reflect the expected number of requests for each type of examination during the ENU project.

OBJECTIVE 4: Various constraints will affect the service capabilities and patient scheduling methods of the Radiology Department during the ENU project. The following are examples of such constraints:

1. Amount of time available in each of the examination rooms (service capacity). The hours of operation, staffing

schedules, expected equipment down time (to be obtained from an inspection of maintenance and repair records), and the amount of scheduled nonproductive time (e.g. committee meetings) all impact on the minutes available.

2. Specific examinations that must be done in-house. The desires of the Radiology Department or the medical staff might dictate that certain examinations cannot be shifted to another hospital.

3. Equipment capabilities. Certain examinations can only be done in certain rooms due to equipment capabilities.

4. The maximum acceptable average waiting time that patients are expected to experience during the EMU. Average patient waiting times for each hour of the day were determined under Objective 2. The Chief of the Radiology Department will consider this information in determining a maximum acceptable expected average waiting time for patients arriving during a one-hour period (Criterion 1).

**OBJECTIVE 5:** After conducting a literature search and considering the information obtained above, alternate scheduling methods will be identified. Aspects of the scheduling method that might be changed include:

1. Alteration of the time allotted for various examinations

2. Alteration of the number and/or type of examinations that are scheduled

3. Alteration of one or more constraints associated with a given scheduling method (i.e. changes in staffing schedules or hours of operation could affect the amount of time available in an examination room)

OBJECTIVE 6: Data collected under previous Objectives will be used to estimate the longest average waiting times expected during the EMU for patients arriving within a one hour period, given an alternate scheduling method.

1. The number of unscheduled patient arrivals expected for each hour of the day will be estimated by applying the hourly distribution of unscheduled patient arrivals (obtained under Objective 2) to the expected workload (obtained under Objective 3). The number of arrivals scheduled hourly under the alternate scheduling method will then be added to obtain the total number of expected patient arrivals for each hour.

2. The expected number of hourly patient arrivals and service capacity during the EMU will be weighed against the hourly number of patient arrivals and service capacity observed during the data collection period to arrive at an estimate of the longest average waiting times expected during the EMU.

OBJECTIVE 7: For the alternate scheduling methods with their particular constraints, the following relationship exists:

$$\text{Examinations done at NACH} + \text{Examinations done at other hospitals} = \text{Total projected workload}$$

The actual objective is to minimize the expenditure of Supplemental Care funds on examinations done at other hospitals, so the objective function would be:

$$\text{Minimize: } \sum \left( \begin{array}{c} \text{cost of the} \\ \text{examination} \end{array} \right) \left( \begin{array}{c} \text{number of each type} \\ \text{of examination done} \\ \text{at other hospitals} \end{array} \right)$$

The constraints associated with a particular scheduling method are most easily expressed in terms of examinations that are done at NACH. To simplify the formulation of the linear programming problem, the minimization objective function involving examinations done at other hospitals can be converted to a maximization of the "payoff" associated with examinations that are done at NACH. If another hospital charges NACH \$50 for doing a procedure, NACH saves \$50 in Supplemental Care funds (the payoff) if it can do the examination in-house. The maximization function would be expressed as:

$$\text{Maximize: } \sum \left( \begin{array}{c} \text{cost of the} \\ \text{examination} \end{array} \right) \left( \begin{array}{c} \text{number of each type} \\ \text{of examination} \\ \text{scheduled at NACH} \end{array} \right)$$

To illustrate the use of linear programming to maximize the payoff of a scheduling method, a hypothetical scenario involving a limited number of examinations and constraints is outlined below:

Examination 1 must be done in room 1 or 2.

Examination 2 can be done in any room.

Examination 3 must be done in room 2 or 3.

Examination 4 can be done in any room.

<u>Examination</u>	<u>Weighted cost</u>	<u>Minutes required for the procedure</u>
1	\$100	45
2	\$50	30
3	\$10	15
4	\$5	10

Room 2 is temporarily closed for the ENU project. The Radiology Department decided that all examination 4's should be done in-house.

Let  $X_{ij}$  = the number of  $i$ th examinations done at NACH in the  $j$ th room during one month.

Objective function:

$$\text{Maximize: } \$100X_{11} + \$50X_{21} + \$50X_{23} + \\ \$10X_{33} + \$5X_{41} + \$5X_{43}$$

Subject to:

$$45X_{11} + 30X_{21} + 10X_{41} \leq \text{minutes available} \\ \text{in Rm \#1 during one month}$$

$$30X_{23} + 15X_{33} + 10X_{43} \leq \text{minutes available} \\ \text{in Rm \#3 during one month}$$

$$X_{41} + X_{43} \geq \text{number of examination 4's} \\ \text{projected for one month}$$

The values obtained for the  $X_{ij}$  will be compared to the projected workload to identify the type and number of examinations that must be referred to other hospitals, and the cost of shifting the examinations to the other hospitals will be calculated.

Although the EMU plan calls for three different combinations of examination rooms to be used during the renovation of the Radiology Department, only two linear programming models will be constructed. Since the General Electric and Picker machines have the same capabilities, the model constructed for the period when the General Electric machine is unavailable will also apply when the Picker machine is unavailable.

## FOOTNOTES

<sup>1</sup>Elwood A. Buffa, Operations Management: The Management of Productive Systems (New York: John Wiley and Sons, Inc., 1976), pp. 301, 328.

<sup>2</sup>See Kenneth R. Ferron, Patricia A. Burke, and Daniel J. O'Connor, Jr., "Radiology Services' Study Improves Productivity, Care," Hospital Progress 63 (June 1982):50; Howard M. Blanken, Geoffrey T. Froese, and Robert B. Toffler, "Patient Scheduling System Improves Productivity," Hospitals 55 (16 April 1981):71-72; and Karl E. Hansen and Larry R. Snider, "Scheduling System Shows Way to Expand," The Modern Hospital 102 (April 1964):110.

<sup>3</sup>See Dov Kanon, "Scheduling System for X-Rays Prevents Overtaxing of Facilities," Hospitals 41 (1 January 1967):87.

<sup>4</sup>See Tali Conine and Debra Aders, "Trim Costs with Two Management Tools," Hospital Financial Management 34 (September 1980):28; Robert B. Conrad et al., "Utilization Study Saved Hospital From Needless Expansion of Radiology Facility," Hospital Financial Management 27 (September 1973):40-48; and Nancy H. Hill and Cengiz Tanverdi, "Radiology Department Study Leads to Improved Productivity," Hospitals 55 (16 April 1981):68-69.

<sup>5</sup>See R.G. Jost et al., "A Computer System to Monitor Radiology Department Activity: A Management Tool to Improve Patient Care," Radiology 145 (November 1982):347-50; and James T. Rhea and Robert P. Germaine, "The Relationship of Patient Waiting Time to Capacity and Utilization in Emergency Room Radiology," Radiology 130 (March 1979):637-41.

<sup>6</sup>Dickenson, p. 225.

<sup>7</sup>Hansen and Snider, p. 112; and Dickenson, p.225.

<sup>8</sup>Ronald L. Arenson and Jack W. London, "Comprehensive Analysis of a Radiology Operations Management Computer System," Radiology 133 (November 1979):356.

<sup>9</sup>Blanken, Froese, and Toffler, p. 71.

<sup>10</sup>James K. McNally, "What Work Measurement Can Accomplish in Radiology," Hospital Financial Management 26 (September 1972):27-34.

<sup>11</sup>Conrad et al., pp. 46-48.



12Jack E. McDaniel, "Two Techniques for Alternatives Analysis," Radiology Management 6 (March 1984):13-15.

13Elwood A. Buffa, Operations Management: The Management of Productive Systems (New York: John Wiley and Sons, Inc., 1976), pp. 301-339.

14Richard A. Johnson, Fremont E. Kast, and James E. Rosenzweig. The Theory and Management of Systems (New York: McGraw-Hill Book Company, 1982), p. 211.

15Roger D. Eck, Operations Research for Business (Belmont, California: Wadsworth Publishing Company, 1976), p. 548.

16Richard I. Levin, Charles A. Kirkpatrick, and David S. Rubin. Quantitative Approaches to Management (New York: McGraw-Hill Book Company, 1982), p. 586.

## II. DISCUSSION

### CURRENT METHOD OF SCHEDULING EXAMINATIONS

The Radiology Department's hours of operation are 0730-1600 Monday through Friday. Radiology technicians are on call to perform emergency procedures outside the normal hours of operation. The Department currently has only one operational examination room, so the total examination room time routinely available is 8.5 hours per day. The room is equipped with a General Electric x-ray machine that is capable of performing general x-rays, mammograms, fluoroscopic and special radiological examinations.

Prior to October 1985, when two examinations rooms were operational, the Radiology Department scheduled patients for mammograms, fluoroscopic and special procedures. As illustrated by the Radiology Daily Procedure Schedule (MACH Form 220) at Appendix B, examinations were scheduled in 45-minute time periods from 0730-1115 and 1300-1600. Gall bladder (OCG) studies, intravenous pyelograms (IVP's), barium enemas (BE's), upper gastrointestinal (UGI) studies and other fluoroscopic or special examinations that require the patient to fast were scheduled in the morning. Studies that do not require the patient to fast--such as arthrograms, venograms, tomograms and mammograms--were scheduled in the afternoon.

The current method of scheduling examinations has evolved

from attempts by the Radiology Department to deal with the constraints of a single operational examination room. Outpatient fluoroscopic and special procedures are scheduled by specific appointment times. General x-ray examinations for outpatients are performed on a "first come, first served" basis. Examinations for inpatients are fit into the work flow on an "on call" basis, which means the Radiology Department notifies the ward to deliver the patient when the room is available to do the examination. All mammograms are sent out to other hospitals and paid for with Supplemental Care funds.

Fluoroscopic and special procedures for outpatients are typically scheduled for three 45-minute time periods beginning at 0900, 0945 and 1300 for each day of the week except Thursday. No fluoroscopic or special examinations are scheduled on Thursdays, because MACH has contracted for the services of a mobile computerized tomography (CT) unit on Thursday afternoons. The MACH radiologist must be available to read CT scans in the mobile unit by noon, so he cannot risk being tied up with a backlog of fluoroscopic or special procedures on that day. The radiologist also attends a continuing education program on the last Friday of each month, so patients are not appointed at 1300 on that day.

Appointments for outpatient fluoroscopic and special procedures are typically booked over a month in advance. The physician writes the maximum acceptable waiting time for an appointment on the request for the examination. If the

Radiology Department has an appointment time available within that time period, the patient is scheduled for the examination. If an appointment is not available, the patient is scheduled for the examination at another facility, and MACH pays for the examination with Supplemental Care funds. No scheduling priority is given for specific types of examinations or for a particular physician. The maximum acceptable waiting time noted on the request is the only factor used to decide whether a given fluoroscopic or special procedure is done at MACH or at some other facility.

Mammograms are currently sent to St. John Hospital in Leavenworth and to Kansas University Medical Center in Kansas City, Kansas. All other examinations are sent to the Veterans Administration Medical Center in Leavenworth.

#### ANALYSIS OF CURRENT OPERATION

Data concerning 751 examinations performed during the Radiology Department's normal operating hours were collected during the four-week study period of 21 March-17 April 1986. The receptionist recorded the time each patient arrived at the department on the Radiology Daily Register (MACH Form 252). The radiology technician recorded the times that each patient entered and departed the examination room on the Patient Control Card (MACH Form 51). Seven data elements concerning each examination were then gleaned from these forms and entered into

a computerized data base. A printout of the data base is provided at Appendix D.

The first three data elements are the day that the examination was performed, the clinic or ward that requested the examination, and the type of examination performed. Legends or explanations for the abbreviations used for these data elements are provided in Appendix D.

The fourth data element is the hour of the day that the patient arrived at the radiology department. Patients arriving from 0730-0829 are identified by "0800" as the arrival hour. Patients arriving from 0830-0929 are identified by "0900", and so on. Since the department closes at 1600, the "1600" arrival hour only applies to patients arriving in the 1530-1600 time period.

The fifth data element is the waiting time experienced by the patient. The waiting time is defined as the number of minutes from the time the patient arrived at the Radiology Department until the patient entered the examination room.

The sixth data element is the service time for the examination. The service time is defined as the number of minutes that the patient actually occupied the examination room.

The seventh data element is the transition time between examinations. The transition time is the number of minutes elapsed from the time one patient departs the examination room until the next patient, who has been waiting, enters the examination room. Transition time is counted only when there is

a patient waiting for an examination. When there is no patient waiting for an examination and the room is empty, it is considered idle time. Since idle time occurred so infrequently, it was tabulated separately from the data base.

The number of examinations, total service time and average service time for each type of examination performed during the study period are listed in Table 1. The overall average service time for general x-ray examinations is 5.7 minutes, compared to a 41.5 minute average service time for fluoroscopic and special procedures. Although the 52 fluoroscopic and special procedures represent only 7 percent of the examinations performed, they account for 35 percent of the total service time.

The average service times for three types of examinations merit comment. The average service time of 12.5 minutes for an abdominal series examination is skewed by an examination involving a trauma patient that took 60 minutes to complete. The other three abdominal series examinations had an average service time of only five minutes. The multiple general x-ray examination refers to patients who underwent more than one general x-ray procedure, which accounts for the relatively long average service time for that type of examination. The radiology technicians thought that the 35 minute service time observed for the arthrograms is less than the true average. Future calculations that involve arthrograms will use 40 minutes as the average service time.

**TABLE 1**  
**EXAMINATION SERVICE TIMES**  
(In Minutes)

Type of Examination	Number of Examinations	Total Service Time	Average Service Time
<b>General X-Rays:</b>			
Chest/Rib	202	663	3.3
Extremities	347	1641	4.7
Head/Sinus	31	273	8.8
Spine	89	891	10.0
Kidneys/Ureters/Bladder	4	24	6.0
Abdominal Series	4	75	12.5
Multiple	22	427	19.4
<b>Total</b>	<b>699</b>	<b>3994</b>	<b>5.7</b>
<b>Fluoroscopic and Special:</b>			
Upper Gastrointestinal	10	283	28.3
Barium Enema	14	602	43.0
Arthrogram	1	35	35.0
Intravenous Pyelogram	16	651	40.7
Tomogram	3	181	60.3
Xerogram	1	60	60.0
Others	7	345	49.3
<b>Total</b>	<b>52</b>	<b>2157</b>	<b>41.5</b>

In addition to the service time required for each examination, the number of examinations completed within a given time depends on the transition time between examinations. Excessive transition times could result from delays caused by incomplete examination requests, patient flow problems, equipment adjustments required for certain procedures, or frequent minor equipment malfunctions. The average transition time observed during the study period was 4.1 minutes.

The time required to complete an examination is actually the sum of the service time and the transition time. By adding

The 4.1 minute average transition time to the overall average service times listed in Table 1, the average completion time for general x-ray examinations is 9.8 minutes, and the average completion time for fluoroscopic and special examinations is 45.6 minutes.

The distribution of patient arrivals for each hour of the day during the study period is shown in Table 2. Almost 40 percent of the patients arrived during the first two hours of the day. Sixty-five percent of the patients undergoing fluoroscopic or special examinations arrived during the first three hours of the day. The scheduled arrivals included 15 patients who were scheduled for 0900, 14 patients who were scheduled for 0945 and six patients who were scheduled for 1300. The Radiology Department had actually scheduled 41 patients for fluoroscopic and special examinations during the study period, but six patients (15 percent) cancelled for various reasons. Unscheduled arrivals for fluoroscopic and special examinations include the inpatient examinations, which were performed "on call", and emergencies.



TABLE 2

DISTRIBUTION OF PATIENT ARRIVALS  
(Numbers and Percentages)

Arrival Hour	General X-Rays		Sched. F&S <sup>a</sup>		Unsched. F&S <sup>b</sup>		Hourly Total	
	(#	x )	(#	x )	(#	x )	(#	x )
0800	177	25.3	7	20.0	1	5.8	185	24.6
0900	99	14.2	12	34.3	3	17.6	114	15.2
1000	86	12.3	10	28.5	1	5.9	97	12.9
1100	77	11.0	--	----	2	11.8	79	10.5
1200	57	8.2	--	----	4	23.5	61	8.1
1300	63	9.0	4	11.4	1	5.9	68	9.1
1400	58	8.3	2	5.7	3	17.6	63	8.4
1500	60	8.6	--	----	2	11.8	62	8.3
1600	22	3.1	--	----	-	----	22	2.9
Total	699		35		17		751	

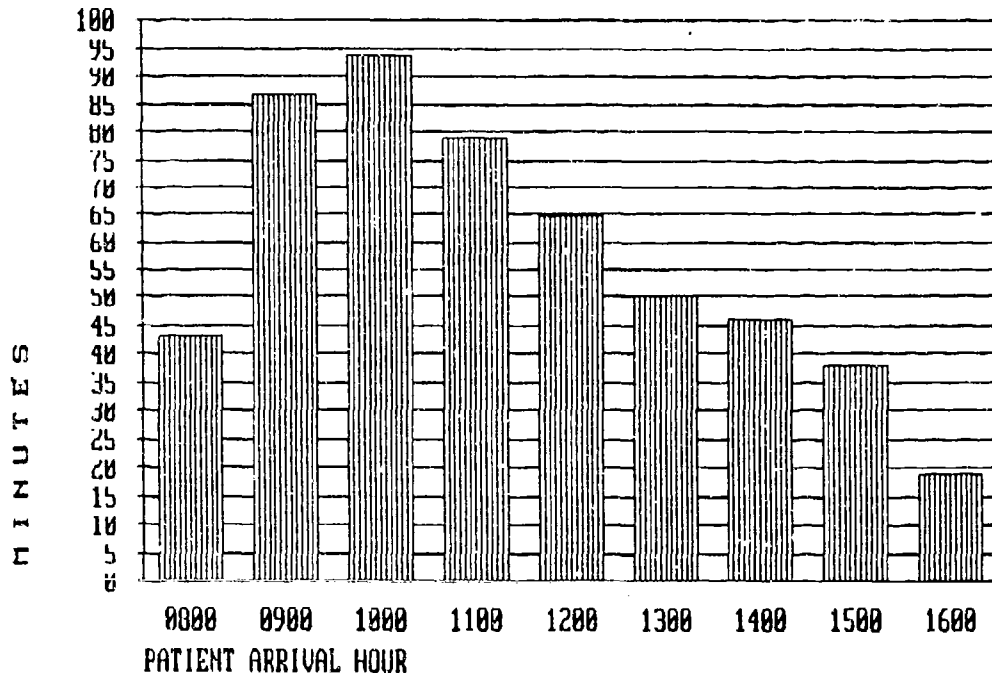
<sup>a</sup>Sched. F&S denotes scheduled fluoroscopic and special examinations.

<sup>b</sup>Unsched. F&S denotes uncheduled fluoroscopic and special examinations.

Figure 1 depicts the average patient waiting time experienced by patients arriving during each hour of the day. The combination of the long service times required for fluoroscopic and special examinations and the large numbers of patients arriving early in the day results in very long waiting times during the morning hours. Patients arriving during the 1000 arrival hour experienced the longest average waiting time of 94 minutes. The overall average waiting time for the 751 patients included in the study period was 62 minutes.

FIGURE 1

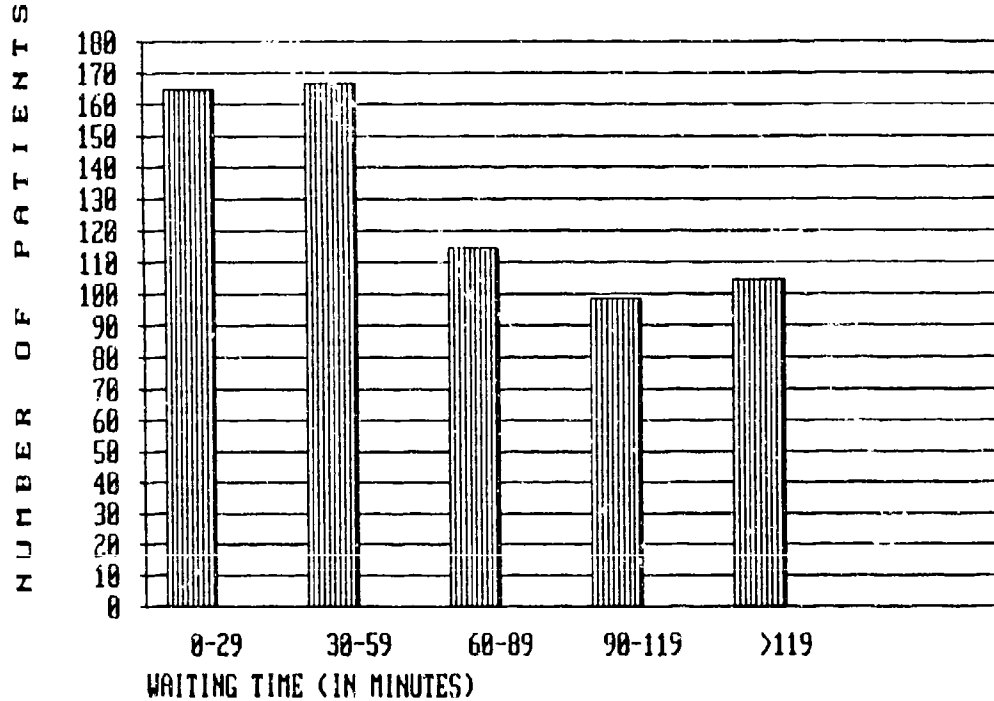
▨ AVERAGE PATIENT WAITING TIMES



The distribution of waiting times was analyzed to see if a few patients with very long waiting times had distorted the average waiting times. The distribution of waiting times is displayed in Figure 2. Since 319 patients (42.5 percent of all patients) experienced waiting times of one hour or more, it was concluded that the average waiting times were not distorted by a few patients with excessive waiting times.

FIGURE 2

▨ DISTRIBUTION OF WAITING TIMES



The status of the examination room at any given moment falls into one of four categories. When a patient is in the room, it is identified as service time. The time between examinations is transition time. Idle time occurs when the room is empty, and no patients are waiting. The room could also be down for maintenance or repair. The utilization of the examination room during the study period is summarized in Table 3. The combination of the service and transition times results in a 90 percent utilization rate for the examination room.

**TABLE 3**  
**EXAMINATION ROOM UTILIZATION**  
**STUDY PERIOD**

Status	Minutes	Percent of Total Time
Service time	6151	60
Transition time	3085	30
Idle time	626	6
Repair and maintenance	413	4

Requests for radiological examinations came from 20 clinics, wards and services during the study period. The number of examinations requested by each is displayed in Table 4. There were 717 outpatient examinations and only 34 inpatient examinations.

**TABLE 4**  
**EXAMINATION REQUESTS BY SERVICE**  
**STUDY PERIOD**

Service	Number	Service	Number
General Outpatient Clinic	194	Physical Therapy	5
Orthopedics	160	Allergy Clinic	2
Family Practice	87	Dental Clinic	2
Medical Exam Clinic	75	Eyes, Ears, Nose and Throat Clinic	1
Emergency Room	72	Mental Health Clinic	1
Internal Medicine	48	Ward 3B	23
Pediatrics	30	Ward 2C	7
U.S. Disciplinary Barracks	15	Ward 2B	3
Obstetrics/Gynecology	10	U.S. Disciplinary Barracks Ward	1
General Surgery	9		
Community Health Clinic	6		

**ESTIMATE OF WORKLOAD DURING THE EMU**

The renovation of the Radiology Department under the EMU

project is scheduled for August 1986 through April 1987. No major changes are expected in the demand for radiological examinations during this period as compared to the prior year. The estimates of the expected workload are based on workload records from the Radiology Department and the Patient Administration Division's monthly report on referrals of Supplemental Care for August 1985 through April 1986. The estimates for each three-month period during the EMU project are contained in Appendix E.

The workload estimates could not simply be extracted from the Radiology Department's monthly workload reports, because the department reports workload differently than the way the workload data was collected during the study period. For example, three different views of the spine for a single patient are counted as three examinations by the Radiology Department, while they would have been counted as a single examination during the study. The summary reports also contain workload performed outside the normal hours of operation (i.e. nights and weekends). The study period only covered workload performed during normal operating hours Monday through Friday during a four-week period. To eliminate such discrepancies, workload data from the Radiology Daily Register (MACH Form 252) were used in making the estimates. The estimates reflect the average number of requests for examinations that are expected during normal operating hours for a four-week period.

## CONSTRAINTS DURING THE EMU

One of the constraints on the operation of the Radiology Department during the EMU concerns the x-ray equipment that will be available. The General Electric will be the only machine available during the first three-month period. It can perform general x-rays, mammograms, fluoroscopic and special procedures. The Phillips and Picker machines will both be available during the second three-month period. The Phillips machine can perform general x-rays, mammograms, intravenous pyelograms, tomograms and xerograms; but no fluoroscopies. The Picker machine has essentially the same capabilities as the General Electric machine. The Phillips and General Electric machines will be available during the last three months of the EMU project.

With only one machine in operation, the amount of examination room time available will be minimal during the first three months of the project. The 170 hours of examination room time that are ostensibly available during normal operating hours in a four-week period are reduced by certain factors. A review of Maintenance Requests (DA Form 2407) for the General Electric machine revealed that it was down for repairs or maintenance an average of 14 hours per four-week period (8.2 percent of the time). *probably invalid statistically*

The contracted mobile computerized tomography service and the continuing education programs routinely take the radiologist out of the department for four hours each Thursday afternoon and

four hours one Friday afternoon a month. Although the examination rooms are still available for general x-ray examinations, fluoroscopic and special procedures cannot be done because the radiologist is not available. These known absences would be taken into account in determining the number of appointments available for a given scheduling system.

Whenever the radiologist is unavailable because of leave, temporary duty, illness, etc., the number of appointments is further reduced. Given the scheduling method in effect during the study period, appointments for 47 fluoroscopic and special procedures would supposedly have been available, but various absences by the radiologist reduced the number available to 41. As discussed earlier, six of the 41 scheduled patients cancelled their appointments, so only 35 (75 percent) of the 47 appointments that would supposedly have been available actually resulted in examinations being performed.

The Radiology Department did not identify any specific procedures that absolutely must be done in-house. A review of the reports on referrals of supplemental care revealed that essentially all types of examinations have been referred to other facilities at some time. The department naturally wants to avoid sending any inpatients or patients requiring only routine x-ray examinations to other hospitals.

As illustrated earlier, the patient waiting time for x-ray examinations at MACH is quite long. An average waiting time of 94 minutes for patients arriving from 0930-1029 was deemed to be

unacceptable. Radiology Department personnel consider 60 minutes to be the maximum acceptable expected average waiting time for patients arriving during any one-hour period if only one x-ray machine is available. The maximum acceptable expected waiting time is 30 minutes when two machines are available.

#### ALTERNATE SCHEDULING METHODS

The opposing objectives of maximizing the number of radiological examinations performed in-house while keeping expected patient waiting times below the maximum acceptable level were the prime considerations in developing alternate scheduling methods. As discussed previously, the long patient waiting times are caused by large numbers of patients arriving early in the day when fluoroscopic and special procedures are performed.

The waiting times experienced by patients arriving within a given one-hour period depend, in part, on the time required to complete the examinations for those patients and the time required to complete the examinations for any patients who arrived during previous hours and are still waiting for examinations. Table 5 displays the average time required to complete the examinations for patients arriving during each hour of the day during the study period, and the average waiting times they experienced.



TABLE 5

AVERAGE EXAMINATION COMPLETION AND PATIENT WAITING TIMES  
STUDY PERIOD  
(In Minutes)

Arrival Hour	Average Daily Arrivals		Average Time Required to Complete Examinations			Cumulative Variance from Service Capacity	Average Patient Waiting Time
	Gen <sup>a</sup>	F&S <sup>b</sup>	Gen	F&S	Total		
0800	8.85	0.40	87	18	105	+45	43
0900	4.95	0.75	49	34	83	+68	87
1000	4.30	0.55	42	25	67	+75	94
1100	3.85	0.10	38	5	43	+58	79
1200	2.85	0.20	28	9	37	+35	65
1300	3.15	0.25	31	11	42	+17	50
1400	2.90	0.25	28	11	39	-4	46
1500	3.00	0.10	29	5	34	-30	38
1600	1.10	--	11	--	11	-49	19

<sup>a</sup>Gen denotes general x-rays.

<sup>b</sup>F&S denotes fluoroscopic and special examinations.

The average daily arrivals for general x-ray and fluoroscopic and special examinations were determined by dividing the number of arrivals in Table 2 by 20, since each four-week period contained 20 days. The average times required to complete the examinations were calculated by multiplying the average daily arrivals for general x-ray and fluoroscopic and special examinations by their average completion times of 9.8 and 45.6 minutes respectively. The cumulative variance from the service capacity for each arrival hour was calculated by subtracting 60 from the total average time required to complete the examinations for that hour, and adding the difference to the cumulative variance from the previous hour. A cumulative

variance greater than zero indicates that, on the average, the workload exceeds the service capacity of the department and a backlog of patients waiting for examinations exists.

The average time required to complete the examinations exceeded 60 minutes for each of the first three hours of the day, with the cumulative variance from the service capacity reaching 75 minutes. The patients arriving from 0930-1029 experienced the longest average waiting time because they had to wait for the backlog of patients from the first two hours of operation to be examined. The average times required to complete the examinations were less than 60 minutes for the remaining hours of the day, and the average patient waiting times continued to decrease during those hours as the backlog of patients diminished. The department did not "catch up" with the backlog of patients until the cumulative variance from the service capacity turned negative during the 1400 arrival hour. Therefore, on the average, the excess workload of the first three hours of operation affected the waiting times for patients arriving up through the 1300 arrival hour. A change in the scheduling method that would change the required examination completion time for any of the first six hours of the day would affect the average waiting times for patients arriving during subsequent hours until 1330.

A scheduling method that shifts patient arrivals into the afternoon hours would reduce the long average waiting times in the morning hours, but shifting the pattern of patient arrivals

would be very difficult to accomplish. Most of the fluoroscopic and special procedures require the patient to fast prior to the examination. Shifting these examinations to the afternoon would increase patient discomfort. General x-ray examinations are not scheduled, so the Radiology Department cannot control the arrival pattern of these patients. It is not feasible to schedule these examinations because of their short duration, their acute nature, and the difficulties that would be encountered in coordinating appointments with a large number of outpatients and requesting physicians. Other authors have reached the same conclusion regarding the feasibility of scheduling general x-ray examinations.<sup>1</sup>

The only apparent method to keep expected patient waiting times below the 60-minute maximum acceptable level with a single operational x-ray machine is to reduce the number of fluoroscopic and special examinations scheduled to be performed in-house. Two alternate scheduling methods are proposed for the first three-month period of the EMU project.

Alternate Scheduling Method #1 is to schedule one fluoroscopic or special procedure at 0900 and one at 1300 daily (as compared to the current method of scheduling such examinations at 0900, 0945 and 1300). The 0900 appointment should be reserved for examinations that require the patient to fast. The 1300 appointment will be used for examinations that do not require the patient to fast. No examinations will be scheduled on Thursdays because of the mobile CT service, and the

1300 appointment will not be scheduled on the day that the radiologist attends the continuing medical education program.

Alternate Scheduling Method #2 is to schedule only one fluoroscopic or special examination at 1300 with no examinations scheduled in the mornings. The exceptions noted above would be made for the mobile CT service and the continuing medical education program.

Unscheduled fluoroscopic and special examinations (i.e. inpatients and outpatient emergencies) will still be performed in-house and all mammograms will still be sent to other facilities under both alternate scheduling methods.

Two x-ray machines will be available during the second and third three-month periods of the EMU. The Phillips and Picker rooms will be operational during the second period and the Phillips and General Electric rooms during the third period. The General Electric and Picker machines have the same capabilities, so the same scheduling alternatives would apply to both time periods. In the subsequent discussion of the alternate scheduling methods, all references to the Picker machine used in the second period would also apply to the use of the General Electric machine in the third period. Two alternate scheduling methods are proposed for the second and third three-month periods of the EMU project.

Alternate Scheduling Method #3 is to perform all general x-ray examinations in the Phillips room. The relatively few tomograms and xerograms (only three per month are estimated)

will also be scheduled for the Phillips machine at 1300. Fluoroscopic and special examinations that require the patient to fast will be scheduled for the Picker room from 0730-1115 daily. Mammograms, arthrograms and venograms will also be scheduled for the Picker room from 0730-1115 daily, and from 1300-1500 each afternoon, except on Thursdays and one Friday each month. The mix of procedures that will be appointed if the service capacity of the department is not sufficient to do all the expected examinations will subsequently be determined with a linear programming technique. The Picker machine will also be used for any unscheduled fluoroscopic and special examinations occurring throughout the day.

Alternate Scheduling Method #4 is to devote both machines to general x-ray examinations from 0730-0830 daily. After 0830, all general x-ray examinations will be performed in the Phillips room. The tomograms and xerograms will also be done in the Phillips room. Fluoroscopic and special examinations that require the patient to fast will be scheduled for the Picker room from 0830-1130 daily. Mammograms, arthrograms and venograms will also be scheduled from 0830-1130 daily, and as outlined above for the afternoon hours. The previous statements regarding the mix of procedures and unscheduled examinations also apply to this scheduling method.

## ESTIMATE OF EXPECTED AVERAGE WAITING TIMES

The first criterion for evaluating the alternate scheduling methods concerns the expected average waiting times for patients arriving within a one-hour period. The maximum acceptable expected average waiting times are 60 minutes when only one examination room is available and 30 minutes when two examination rooms are available.

The expected average waiting times during the EMU project for each alternate scheduling method are estimated as follows:

1. The expected hourly distribution of patient arrivals, given the particular scheduling method, is determined.

2. The expected average times required to complete the examinations for patients arriving during each hour of the day and the cumulative variances from the service capacity are calculated. The department is expected to experience, on the average, a continuous backlog of patients during consecutive hours of operation that the cumulative variance remains positive. The break-even point is reached when the cumulative variance from the service capacity turns negative. If the cumulative variance from the service capacity remains negative, the patient waiting times for arrival hours subsequent to the break-even point will not be influenced by a backlog of patients and are expected to average less than 30 minutes.

3. The differences between the expected average times required to complete the examinations during the EMU project and

the average time required to complete the examinations during the study period are calculated.

4. The cumulative differences in the time required to complete the examinations are used to adjust the waiting times observed during the study period to estimate the expected average waiting times during the EMU project. The adjustment of waiting times applies only to the consecutive hours of the day until the break-even point is reached.

Alternate Scheduling Method #1

As outlined previously, Alternate Scheduling Method #1 for the first three-month period of the EMU project would schedule fluoroscopies and special examinations at 0900 and 1300 daily, with some exceptions. The expected hourly distribution of patient arrivals for this scheduling method is shown in Table 6.

TABLE 6

EXPECTED DISTRIBUTION OF PATIENT ARRIVALS  
ALTERNATE SCHEDULING METHOD #1

Arrival Hour	General X-Rays	Sched. F&S	Unsched. F&S	Total F&S
0800	187	7	1	8
0900	105	8	3	11
1000	91	-	1	1
1100	81	-	2	2
1200	61	-	4	4
1300	66	4	1	5
1400	61	2	3	5
1500	63	-	2	2
1600	23	-	-	-
Total	738	21	17	38

The expected distribution of general x-rays is based on the assumption that the hourly distribution of unscheduled patient arrivals during the EMU will be the same as that observed in the study period. The expected average of 738 general x-rays per four-week period for August-October 1986 (from Appendix E) was multiplied by the hourly percentage distribution of general x-rays from Table 2. The number and distribution of unscheduled fluoroscopic and special examinations (inpatients and outpatient emergencies) are assumed to remain the same as that observed during the study period. The elimination of the 0945 appointment slot in this scheduling method is reflected in the number and distribution of the scheduled fluoroscopic and special examinations by the elimination of 14 patient arrivals corresponding to those observed in the study period (see discussion concerning Table 2).

Table 7 shows the expected average times required to complete the examinations for patients arriving during each hour of the day and the cumulative variance from the service capacity. The calculation methods used and the setup of Table 7 are essentially the same as for Table 5. Since the cumulative variance from the service capacity turned negative during the 1400 arrival hour, the adjustments to waiting times (see Tables 9 and 10) will end with the 1300 arrival hour, and the waiting times during subsequent hours are expected to average less than 30 minutes.



TABLE 7

EXPECTED AVERAGE EXAMINATION COMPLETION TIMES  
AND CUMULATIVE VARIANCE FROM SERVICE CAPACITY  
ALTERNATE SCHEDULING METHOD #1

Arrival Hour	Average Daily Arrivals		Average Time Required to Complete Examinations (In minutes)			Cumulative Variance from Service Capacity (In minutes)
	Gen.	F&S	Gen.	F&S	Total	
0800	9.35	0.40	92	18	110	+50
0900	5.23	0.55	51	25	76	+66
1000	4.55	0.05	45	2	47	+53
1100	4.05	0.10	40	5	45	+38
1200	3.05	0.20	30	9	39	+17
1300	3.30	0.25	32	11	43	0
1400	3.05	0.25	30	11	41	-19
1500	3.15	0.10	31	5	36	-43
1600	1.15	--	11	--	11	-62

Table 8 depicts the differences between the study period and Alternate Scheduling Method #1 in the average times required to complete the examinations for patients arriving during each hour of the day up to the break-even point.

TABLE 8

DIFFERENCES IN AVERAGE EXAMINATION COMPLETION TIMES REQUIRED  
ALTERNATE SCHEDULING METHOD #1  
(In Minutes)

Arrival Hour	Study Period (Observed)	Alternate Method #1 (Expected)	Difference	Cumulative Difference
0800	105	110	+5	+5
0900	83	76	-7	-2
1000	67	47	-20	-22
1100	43	45	+2	-20
1200	37	39	+2	-18
1300	42	43	+1	-17

Table 9 shows the estimates of the expected average waiting times associated with Alternate Scheduling Method #1 resulting from the adjustment of waiting times observed during the study period by the cumulative difference in the average examination completion times required. The expected average waiting times for the 0900 and 1000 arrival hours exceed the 60-minute maximum acceptable expected average waiting time.

**TABLE 9**  
**ESTIMATE OF EXPECTED AVERAGE WAITING TIMES**  
**ALTERNATE SCHEDULING METHOD #1**  
**(In Minutes)**

Arrival Hour	Study Period Average Patient Waiting Time (Observed)	Cumulative Difference in Average Examination Completion Time (+ or -)	Expected Average Patient Waiting Time
0800	47	+5	52
0900	87	-2	85
1000	94	-22	72
1100	79	-20	59
1200	65	-18	47
1300	50	-17	33

**ALTERNATE SCHEDULING METHOD #2**

The estimate of the expected average waiting times for Alternate Scheduling Method #2 was calculated in the same manner as above and is shown in Appendix F in Tables 20-23. Tables 20-23 correspond directly to Tables 6-9 above. The longest expected average waiting time associated with Alternate Scheduling Method #2 is 51 minutes, which meets the 60-minute

criterion for the maximum acceptable waiting time.

Alternate Scheduling Method #3

The estimate of expected average waiting times for Alternate Scheduling Method #3 involves patient arrivals for two examination rooms. The expected distribution of patient arrivals for the Phillips room is shown in Table 10. The expected average of 656 general x-rays per four-week period for November 1986 through January 1987 (from Appendix E) was distributed according to the hourly distribution observed during the study period. The three scheduled fluoroscopic and special examinations represent the tomograms and xerograms.

TABLE 10

EXPECTED DISTRIBUTION OF PATIENT ARRIVALS  
ALTERNATE SCHEDULING METHOD #3  
(Phillips Room)

Arrival Hour	General X-Rays	Sched. F&S
0800	166	-
0900	93	-
1000	81	-
1100	72	-
1200	54	-
1300	59	3
1400	55	-
1500	56	-
1600	20	-
Total	656	3

The expected number of scheduled patient arrivals for the

Picker room, displayed in Table 11, is based on the observation during the study period that the number of scheduled examinations actually performed was only 75 percent of the number of appointments that would supposedly have been available under the scheduling method in effect. Alternate Scheduling Method #3 would supposedly provide one hundred 45-minute appointments from 0730-1115 and sixty 30-minute appointments (the radiology technicians estimate that mammograms take 30 minutes to complete) from 1300-1500 during a four-week period. The actual numbers of scheduled patient arrivals are expected to be 75 and 45 during the respective time periods. This calculation was not made for Alternate Scheduling Methods #1 and #2 because the expected patient arrivals for those methods were estimated by adjusting the numbers of actual patient arrivals observed during the study period. The number and distribution of unscheduled fluoroscopic and special examinations are expected to be the same as observed during the study period.

TABLE 11

EXPECTED DISTRIBUTION OF PATIENT ARRIVALS  
 ALTERNATE SCHEDULING METHOD #3  
 (Picker Room)

Arrival Hour	Sched. F&S	Unsched. F&S	Total F&S	Mammograms
0800	20	1	21	--
0900	20	3	23	--
1000	20	1	21	--
1100	15	2	17	--
1200	--	4	4	--
1300	--	1	1	15
1400	--	3	3	20
1500	--	2	2	10
1600	--	-	-	--
Total	75	17	92	45

The expected average examination completion times and the cumulative variance from the service capacity for the Phillips and Picker rooms are shown in Tables 12 and 13. The cumulative variance from the service capacity in the Picker room is constantly negative, so the waiting times experienced by patients examined in the room are expected to average less than 30 minutes throughout the day. The same is true for the Phillips room beginning with the 1000 arrival hour.

TABLE 12

EXPECTED AVERAGE EXAMINATION COMPLETION TIMES  
AND CUMULATIVE VARIANCE FROM SERVICE CAPACITY  
ALTERNATE SCHEDULING METHOD #3  
(Phillips Room)

Arrival Hour	Average Daily Arrivals		Average time Required to Complete Examinations (In minutes)			Cumulative Variance from Service Capacity (In minutes)
	Gen.	F&S	Gen.	F&S	Total	
0800	8.30	--	81	--	81	+21
0900	4.65	--	46	--	46	+7
1000	4.05	--	40	--	40	-13
1100	3.60	--	35	--	35	-38
1200	2.70	--	26	--	26	-72
1300	2.95	0.15	29	10	39	-93
1400	2.75	--	27	--	27	-126
1500	2.80	--	27	--	27	-153
1600	1.00	--	10	--	10	-173

TABLE 13

EXPECTED AVERAGE EXAMINATION COMPLETION TIMES  
AND CUMULATIVE VARIANCE FROM SERVICE CAPACITY  
ALTERNATE SCHEDULING METHOD #3  
(Picker Room)

Arrival Hour	Average Daily Arrivals		Average Time Required to Complete Examinations (In minutes)			Cumulative Variance from Service Capacity (In minutes)
	F&S	Memmo	F&S	Memmo	Total	
0800	1.05	--	48	--	48	-12
0900	1.15	--	52	--	52	-20
1000	1.05	--	48	--	48	-32
1100	0.85	--	39	--	39	-53
1200	0.20	--	9	--	9	-104
1300	0.05	0.75	2	23	25	-139
1400	0.15	1.10	7	33	37	-162
1500	0.10	0.50	5	15	20	-202
1600	--	--	--	--	--	-232

The differences between Alternate Scheduling Method #3 and

the study period in the average examination completion times required for the Phillips room are calculated in Table 14 and are used to calculate the expected average patient waiting times for the 0800 and 0900 arrival hours in Table 15. The 30-minute waiting time criterion is also met in the Phillips room under Alternate Scheduling Method #3.

TABLE 14

DIFFERENCES IN AVERAGE EXAMINATION COMPLETION TIMES REQUIRED  
ALTERNATE SCHEDULING METHOD #3  
(Phillips Room)  
(In Minutes)

Arrival Hour	Study Period (Observed)	Alternate Method #1 (Expected)	Difference	Cumulative Difference
0800	105	81	-24	-24
0900	83	46	-37	-61

TABLE 15

ESTIMATE OF EXPECTED AVERAGE WAITING TIMES  
ALTERNATE SCHEDULING METHOD #3  
(Phillips Room)  
(In Minutes)

Arrival Hour	Study Period Average Patient Waiting Time (Observed)	Cumulative Difference in Average Examination Completion Time (+ or -)	Expected Average Patient Waiting Time
0800	47	-24	23
0900	87	-61	26

Alternate Scheduling Method #4

Alternate Scheduling Method #4 would schedule fewer

patients for examinations than Alternate Scheduling Method #3. Since Alternate Scheduling Method #3 meets the 30-minute waiting time criterion for both examinations rooms, the same can be expected for Alternate Scheduling Method #4.

#### OPTIMAL MIX OF SCHEDULED EXAMINATIONS

The final step in determining the optimal method for scheduling radiological examinations during the EMU project is the use of linear programming to determine the mix of scheduled examinations to be done at MACH that will minimize the expenditure of Supplemental Care funds for examinations performed at other hospitals. However, the linear programming technique is not needed to determine the optimal mix of scheduled examinations for the first three-month period of the EMU project. Alternate Scheduling Method #2, which schedules one fluoroscopic or special examination per day at 1300, is the only scheduling method that meets the 60-minute maximum allowable average waiting time criterion. Fluoroscopic and special examinations that require the patient to fast should not be scheduled at 1300; so arthrograms, tomograms and venograms are the only procedures that can be scheduled under Alternate Scheduling Method #2. Only seven of these examinations are expected to be requested during each four-week period (Appendix E). All seven examinations would easily be accommodated in the schedule. The linear programming technique is not needed to



determine the optimal mix of scheduled examinations because the time available is not a constraint.<sup>2</sup>

Alternate Scheduling Methods #3 and #4 meet the waiting time criterion for the second and third three-month periods of the EMU project. Two examination rooms will be available during these time periods, but the only scheduled examinations performed in the Phillips room will be a small number of tonograms and xerograms, so linear programming is not needed to determine an optimal mix of scheduled examinations for the room.

A linear programming model is now developed to determine the optimal mix of examinations to be scheduled for the Picker room during the second three-month period of the EMU project under Alternate Scheduling Method #3. The scheduling constraints that apply to the Picker room would also apply to the General Electric room during the final three months of the EMU project, so separate models will not be constructed for that time period.

As discussed in the introduction to this study, an objective function that maximizes the "payoff" of examinations scheduled to be done at MACH can be used in a linear programming model to minimize the expenditure of supplemental care funds for examinations sent out to other hospitals:

Maximize: Z =	cost of the examination	number of each type of examination scheduled at MACH
---------------	-------------------------	--

where Z is the dollar value of the payoff realized from the examinations scheduled at MACH, and the cost of the examination is the amount MACH would have to pay another hospital to do the examination.

The following variables are used to designate the number of each examination to be scheduled in the Picker room:

X1 = Upper gastrointestinal	X6 = Arthrogram
X2 = Barium Enema	X7 = Venogram
X3 = Barium Swallow	X8 = Intravenous Pyelogram
X4 = Gall Bladder	X9 = Other Fluoroscopic and Special
X5 = Small Bowel Follow-Through	X10 = Mammogram

The amounts charged by other hospitals for the above examinations were obtained from the Patient Administration Division. Using these charges, the objective function becomes:

$$\text{Maximize: } Z = \$39X_1 + \$80X_2 + \$15X_3 + \$33X_4 + \$60X_5 \\ + \$120X_6 + \$130X_7 + \$110X_8 + \$175X_9 + \$60X_{10}$$

The model addresses three constraints: (1) the time available for scheduled examinations that must be performed in the morning, (2) the total time available for scheduled examinations, and (3) constraint inequalities that prevent the model from providing a quantity of an examination to be scheduled that exceeds the expected demand for that particular examination.

The constraint for the time available for scheduled examinations that must be performed in the morning is expressed

as:

$$32X_1 + 47X_2 + 15X_3 + 20X_4 + 60X_5 \\ + 0X_6 + 0X_7 + 45X_8 + 53X_9 + 0X_{10} \leq 4140 \text{ minutes}$$

The non-zero coefficients of the variables represent the average times required to complete the examinations. These times were calculated from observations made during the study period or were estimated by the radiology technicians if the particular examination was not performed during the study period. The coefficients for X6, X7 and X10 are zeros because arthrograms, venograms and mammograms do not require the patient to fast. Alternate Scheduling Method #3 calls for examinations to be scheduled from 0730 to 1115 daily. Taking into account the 8.2 percent downtime for maintenance and repairs that was noted in the review of the maintenance records, the 4140 minutes (69 hours) available for scheduled examinations that must be performed in the morning is calculated as follows:

$$(3.75 \text{ hours/day})(20) - (3.75)(20)(.082) = 69 \text{ hours per} \\ \text{4-week period}$$

The second constraint is the total time available to do scheduled examinations. This constraint is expressed as:

$$32X_1 + 47X_2 + 15X_3 + 20X_4 + 60X_5 + 45X_6 \\ + 60X_7 + 45X_8 + 53X_9 + 30X_{10} \leq 5790 \text{ minutes}$$

The coefficients representing the time required to complete

arthrograms, venograms and mammograms are now in the constraint inequality. Alternate Scheduling Method #3 calls for examinations to be scheduled from 1300 to 1500 on 15 days in each four-week period, which provides 27.5 additional hours of available examination time according to the following calculation:

$$(2 \text{ hours/day})(15) - (2)(15)(.082) = 27.5 \text{ hours per 4-week period}$$

The third constraint is expressed as ten separate constraint inequalities that will prevent the model from generating a solution that calls for more of a particular examination to be scheduled than is expected to be demanded. The expected demand for each type of examination is shown in Appendix E, but these figures include both scheduled and unscheduled examinations. The numbers of unscheduled examinations observed in the study period were subtracted from the quantities shown in Appendix E, so that the constants in the following constraint inequalities represent the expected demand for scheduled examinations during a four-week period.

$$\begin{array}{lll} 0.75X1 \leq 28 & 0.75X5 \leq 2 & 0.75X8 \leq 15 \\ 0.75X2 \leq 15 & 0.75X6 \leq 2 & 0.75X9 \leq 1 \\ 0.75X3 \leq 4 & 0.75X7 \leq 2 & 0.75X10 \leq 60 \\ 0.75X4 \leq 5 & & \end{array}$$

The coefficient for each of the variables is 0.75 because the number of examinations actually performed during the study period was 25 percent less than the number of examinations that supposedly could have been scheduled. Patient cancellations and the unavailability of the radiologist because of leave, temporary duty, illness, etc., resulted in 35 scheduled examinations being performed when 47 appointments were supposedly available.

The model was run on a linear programming computer program. The printout of the optimal solution generated by the computer appears in Appendix G. The solution is also displayed in a more comprehensible format in Table 16.

TABLE 16  
OPTIMAL MIX OF SCHEDULED EXAMINATIONS  
ALTERNATE SCHEDULING METHOD #3

Examinations	Variable	Number of Exams to be Scheduled	Number of Exams Expected to be Performed	Expected Demand
Upper Gastrointestinal	X1	33.3	25	28
Barium Enema	X2	20	15	15
Barium Swallow	X3	0	0	4
Gall Bladder	X4	6.7	5	5
Small Bowel Follow-Through	X5	0	0	2
Arthrogram	X6	2.7	2	2
Venogram	X7	2.7	2	2
Intravenous Pyelogram	X8	20	15	15
Other Fluoroscopic and Special	X9	1.3	1	1
Hammogram	X10	80	60	60

The values of the primal variables in the computer printout correspond to the numbers of examinations to be scheduled. The numbers of examinations expected to be performed are 75 percent of the numbers of examinations to be scheduled. Alternate Scheduling Method #3 is expected to accommodate all of the demand for examinations except for three upper gastrointestinal, four barium swallow and two small bowel follow-through examinations. MACH would have to pay \$297 to have these examinations performed at another hospital.

The linear programming model to determine the optimal mix of examinations to be scheduled for the Picker room under Alternate Scheduling Method #4 for the second three-month period of the ENU project is almost identical to the above model. The constants for the first two constraint inequalities are the only numbers that change. Alternate Scheduling Method #3 provides three hours each morning for scheduled examinations, so the time available during the morning in a four-week period drops from 4140 to 3300 minutes. The total time available drops from 5790 to 4950 minutes. The computer printout of the optimal solution for this model is shown in Appendix H. The comparison of the numbers of examinations expected to be scheduled, performed and demanded is presented in Table 17.

TABLE 17

OPTIMAL MIX OF SCHEDULED EXAMINATIONS  
ALTERNATE SCHEDULING METHOD #4

Examinations	Variable	Number of Exams to be Scheduled	Number of Exams Expected to be Performed	Expected Demand
Upper Gastrointestinal	X1	7	5	28
Barium Enema	X2	20	15	15
Barium Swallow	X3	0	0	4
Gall Bladder	X4	6.7	5	5
Small Bowel				
Follow-Through	X5	0	0	2
Arthrogram	X6	2.7	2	2
Venogram	X7	2.7	2	2
Intravenous Pyelogram	X8	20	15	15
Other Fluoroscopic and Special	X9	1.3	1	1
Mammogram	X10	80	60	60

Twenty-three upper gastrointestinal, four barium swallow and two small bowel follow-through examinations would be sent to other hospitals under Alternate Scheduling Method #4. These procedures would cost MACH #1077 per four-week period.

The models for Alternate Scheduling Methods #3 and #4 were each run a second time to see what the optimal mix of scheduled examinations would be if the projected demand for each type of examination increased by 25 percent. The computer printouts of the results are at Appendixes I and J. The comparison of the numbers of examinations to be scheduled, performed and demanded are displayed in Tables 18 and 19.

TABLE 1E

OPTIMAL MIX OF SCHEDULED EXAMINATIONS  
 ALTERNATE SCHEDULING METHOD #3  
 (25% Workload Increase)

Examinations	Variable	Number of Exams to be Scheduled	Number of Exams Expected to be Performed	Expected Demand
Upper Gastrointestinal	X1	0	0	35
Barium Enema	X2	24.7	19	19
Barium Swallow	X3	0	0	5
Gall Bladder	X4	0	0	6
Small Bowel Follow-Through	X5	0	0	3
Arthrogram	X6	4	3	3
Venogram	X7	4	3	3
Intravenous Pyelogram	X8	25.3	19	19
Other Fluoroscopic and Special	X9	1.3	1	1
Mammogram	X10	100	75	75

The optimal mix of scheduled examinations under Alternate Scheduling Method #3 with a 25 percent increase in expected demand would send 35 upper gastrointestinal, five barium swallow, six gall bladder and three small bowel follow-through examinations to other hospitals at a cost of \$1785. In addition to the above examinations, 14 barium enemas would be sent out under Alternate Scheduling Method #4 for a total cost of \$2905.



TABLE 19

OPTIMAL MIX OF EXAMINATIONS  
 ALTERNATE SCHEDULING METHOD #4  
 (25% Workload Increase)

Examinations	Variable	Number of Exams to be Scheduled	Number of Exams Expected to be Performed	Expected Demand
Upper Gastrointestinal	X1	0	0	35
Barium Enema	X2	6.8	5	19
Barium Swallow	X3	0	0	5
Gall Bladder	X4	0	0	6
Small Bowel				
Follow-Through	X5	0	0	3
Arthrogram	X6	4	3	3
Venogram	X7	4	3	3
Intravenous Pyelogram	X8	25.3	19	19
Other Fluoroscopic and Special	X9	1.3	1	1
Neurogram	X10	100	75	75

## FOOTNOTES

<sup>1</sup>Howard M. Blanken, Geoffrey T. Frome, and Robert B. Toffler, "Patient Scheduling System Improves Productivity," Hospitals 55 (16 April 1981):71.

<sup>2</sup>Richard I. Levin, Charles A. Kirkpatrick, and David S. Runib. Quantitative Approaches to Management (New York: McGraw-Hill Book Company, 1982), p. 335.

### III. CONCLUSIONS AND RECOMMENDATIONS

#### CONCLUSIONS

This study was to determine the optimal method of scheduling radiological examinations during the electrical-mechanical upgrade project at Munson Army Community Hospital. Since the hospital will have only one examination room during the first three months and two examination rooms during the final six months of the project, two alternate scheduling methods were formulated and evaluated for each of the periods.

Alternate Scheduling Method #1 would eliminate the 0945 appointment slot from the current method of scheduling fluoroscopic and special examinations at 0900, 0945 and 1300. The analysis revealed that the average waiting times for patients arriving during the 0900 and 1000 arrival hours would be 85 and 72 minutes respectively, which exceed the 60-minute maximum average waiting time criterion.

Alternate Scheduling Method #2 would eliminate both the 0900 and 0945 appointment slots. The longest expected average patient waiting time under this scheduling method is 51 minutes for the 0900 arrival hour, which meets the waiting time criterion. Alternate Scheduling Method #2 is consequently selected as the optimal scheduling method for the first three months of the EMU project. Since the number of appointments

that will be available for the remaining 1300 appointments. If it exceeds the expected demand for examinations at that hour, it was not necessary to use linear programming to determine the optimal mix of examinations to be scheduled.

Alternate Scheduling Method #3 devotes the Picker or General Electric examination rooms to scheduled examinations from 0730-1115 and 1300-1500 daily during the last six months of the EMU project. The analysis revealed that the service capacity of this room would exceed the average time that would be required to complete the examinations for each arrival hour of the day, so patient waiting time is expected to average less than 30 minutes.

The Phillips room is left to perform all the general x-ray examinations. Although the average time required to complete the examinations would exceed the service capacity of the Phillips room during the 0800 arrival hour, the expected average patient waiting times are only 23 and 26 minutes for the 0800 and 0900 arrival hours, so the 30-minute patient waiting time criterion is met by both examination rooms under Alternate Scheduling Method #3.

Alternate Scheduling Method #4 devotes both available examination rooms to general x-ray examinations from 0730-0830 daily. This results in a 45-minute reduction in the time available for scheduled examinations in the Picker and General Electric examination rooms. Since Alternate Scheduling Method #4 would schedule fewer examinations than Alternate Scheduling

Method #3, Alternate Scheduling Method #4 will also meet the 30-minute patient waiting time criterion.

The optimal mix of examinations to be scheduled was determined through linear programming techniques for both scheduling method alternatives. Alternate Scheduling Method #3 nearly meets the expected demand for examinations. It is projected that only nine patients would be sent to other hospitals for examinations costing a total of \$297 in a four-week period.

The optimal mix of examinations to be scheduled under Alternate Scheduling Method #4 would fall short of the expected demand by 29 patients. The examinations performed by other hospitals for these patients would cost the hospital \$1077 per four-week period.

Both alternate scheduling methods meet the waiting time criterion. Alternate Scheduling Method #3 is selected as the optimal scheduling method for the final six months of the EMU project because it would send 20 fewer patients to other hospitals for examinations each four-week period at a savings of \$780.

#### RECOMMENDATIONS

Conversion from the current method of scheduling examinations to Alternate Scheduling Method #2 would force NACH to pay for about 30 additional fluoroscopic and special

examinations with Supplemental Care funds every four weeks. Assuming the distribution of the examinations sent out is the same as the distribution of examinations that are expected to be demanded (Appendix E), the 30 examinations would cost MACH approximately \$2250.

The Patient Administration Division would be affected by a change to Alternate Scheduling Method #2. The two Health Benefits Advisors are responsible for scheduling patients for examinations and for all the other administrative matters associated with the referral of examinations. They would have to shoulder the administrative burden of 30 additional referrals every four weeks.

This study identified the optimal scheduling method for a given set of constraints and criteria. The 60-minute maximum acceptable average waiting time criterion was established before the costs of meeting it were known. The additional costs identified above--monetary and administrative--should be compared to the benefits of reducing the longest hourly average patient waiting time from 94 to 51 minutes before Alternate Scheduling Method #2 is adopted.

Alternate Scheduling Method #3 calls for 80 mammograms to be scheduled during each four-week period. The Radiology Department should schedule one mammogram each morning in addition to the four that would be scheduled each afternoon in order to meet the projected demand.

The maximum acceptable waiting time for an appointment that

is noted on the examination request should no longer be the only factor used to decide whether a given fluoroscopic or special procedure is done at MACH or at some other facility. By comparing the examinations to be scheduled in Tables 16 and 18, it can be seen that the upper gastrointestinal examinations should be given priority for referral under Supplemental Care if the demand for examinations that is actually experienced during the last six months of the EMU project exceeds the projections in Appendix E.





**RADIOLOGY DAILY PROCEDURE SCHEDULE**

DATE \_\_\_\_\_

EXAMINATION	PATIENT INFORMATION	DOCTOR	INITIAL	RESULTS
0730 Hours	NAME			
	SSN			
	PHONE #			
0815 Hours	NAME			
	SSN			
	PHONE #			
0900 Hours	NAME			
	SSN			
	PHONE #			
0945 Hours	NAME			
	SSN			
	PHONE #			
1030 Hours	NAME			
	SSN			
	PHONE #			
1300 Hours	NAME			
	SSN			
	PHONE #			
1345 Hours	NAME			
	SSN			
	PHONE #			
1430 Hours	NAME			
	SSN			
	PHONE #			
1515 Hours	NAME			
	SSN			
	PHONE #			
On-call	NAME			
	SSN			
	PHONE #			
On-call	NAME			
	SSN			
	PHONE #			

APPENDIX C

MACH, Ft Leavenworth, KS 66027

NAME \_\_\_\_\_

SSN \_\_\_\_\_

DOB \_\_\_\_\_

\_\_\_\_\_ DOB

\_\_\_\_\_ SSN

\_\_\_\_\_ NAME

MACH Form 51  
15 May 85 (Rev)  
No 1839-1000-feb 86

MACH, Ft Leavenworth, KS 66027

## APPENDIX D

### STUDY PERIOD DATA BASE

#### Explanation of Data Elements

Column #1: Record number

The computer program consecutively numbers each record as the data elements are entered into the data base.

Column #2: Day that the examination was performed

FRI1 stands for Friday of the first week, MON3 stands for Monday of the third week, etc.

Column #3: Service that requested the examination

The abbreviations stand for the following services:

ALGY	Allergy Clinic	OBGY	Obstetrics/Gynecology
COHK	Community Health Service	ORTH	Orthopedics
DENT	Dental Clinic	PEDS	Pediatrics
EENT	Eyes, Ears, Nose and Throat Clinic	PT	Physical Therapy
ENER	Emergency Room	SURG	General Surgery
FAMP	Family Practice Clinic	WD2B	Ward 2B
GOPC	General Outpatient Clinic	WD2C	Ward 2C
INTM	Internal Medicine	WD3B	Ward 3B
MEDX	Medical Exam Clinic	DDDB	U.S. Disciplinary Barracks Ward
MENT	Mental Health Clinic	USDB	U.S. Disciplinary Barracks Clinic

Column #4: Type of examination performed

The abbreviations stand for the following types of examinations:

ABD	Abdominal Series	KUB	Kidneys/Ureters/Bladder
ARTH	Arthrogram	MULT	Multiple Examinations
BE	Barium Enema	SPEC	Other Special Examinations
CHST	Chest/Ribs	SPIN	Spine
EXTR	Extremities	TOMO	Tomogram
FLUR	Other Fluoroscopic	UGI	Upper Gastrointestinal
HEAD	Head/Sinus	XERO	Xerogram
IVP	Intravenous Pyelogram		

**Column #5: Arrival hour**

Hour of the day that the patient arrived in the radiology department is noted as follows:

0800:	0730-0829	1300:	1230-1329
0900:	0830-0929	1400:	1330-1429
1000:	0930-1029	1500:	1530-1529
1100:	1030-1129	1600:	1530-1600
1200:	1130-1229		

**Column #6: Waiting time**

The waiting time is the number of minutes from the time the patient arrived at the Radiology Department until the patient entered the examination room.

**Column #7: Service time**

The service time is the number of minutes that the patient actually occupied the examination room.

**Column #8: Transition time**

The transition time is the number of minutes elapsed from the time a patient departs the examination room until the next patient, who has been waiting, enters the examination room.

LIST FOR DAY='FRI1'

00001	FRI1	ORTH	EXTR	0800	10	5	15
00002	FRI1	MEDX	MULT	0800	36	5	0
00003	FRI1	USDB	SPIN	0800	28	15	0
00004	FRI1	USDB	EXTR	0800	36	4	3
00005	FRI1	SURG	CHST	0800	47	4	1
00006	FRI1	ORTH	EXTR	0800	52	2	3
00007	FRI1	USDB	EXTR	0800	49	6	9
00008	FRI1	USDB	SPIN	0800	68	5	5
00009	FRI1	GOFC	SPIN	0800	68	7	7
00010	FRI1	MEDX	CHST	0800	168	5	1
00011	FRI1	GOFC	EXTR	0800	116	5	21
00012	FRI1	WD3B	CHST	0800	104	5	2
00013	FRI1	GOFC	HEAD	0800	167	4	10
00014	FRI1	FAMP	BE	0800	45	45	12
00015	FRI1	INTM	BE	1000	166	45	7
00016	FRI1	GOFC	EXTR	0900	283	3	0
00017	FRI1	EMER	EXTR	1100	5	5	20
00018	FRI1	GOFC	EXTR	0900	286	5	0
00019	FRI1	GOFC	EXTR	0900	295	4	1
00020	FRI1	FAMP	SPIN	0900	274	11	10
00021	FRI1	GOFC	CHST	0900	285	4	0
00022	FRI1	FAMP	EXTR	1000	271	18	2
00023	FRI1	FAMP	SPIN	1000	273	2	4
00024	FRI1	GOFC	EXTR	1000	322	5	0
00025	FRI1	FAMP	EXTR	1100	283	5	2
00026	FRI1	EMER	MULT	1100	5	80	0
00027	FRI1	USDB	EXTR	1300	192	5	0
00028	FRI1	GOFC	EXTR	1300	177	4	0
00029	FRI1	GOFC	CHST	1300	178	3	5
00030	FRI1	GOFC	SPIN	1300	160	6	0
00031	FRI1	GOFC	CHST	1300	173	3	14
00032	FRI1	SURG	EXTR	1500	100	3	1
00033	FRI1	PEDS	EXTR	1500	98	4	4
00034	FRI1	GOFC	CHST	1500	97	3	0
00035	FRI1	PEDS	EXTR	1500	90	3	8
00036	FRI1	WD3B	CHST	1600	0	5	0
00037	FRI1	WD3B	CHST	1600	19	2	0
00038	FRI1	EMER	MULT	1500	5	65	0
00039	FRI1	EMER	EXTR	1600	55	3	0
00040	FRI1	INTM	SPIN	1600	52	4	0

LIST FOR DAY='MON1'

00041	MON1	ORTH	SPIN	0800	24	2	8
00042	MON1	GOPC	EXTR	0800	35	4	0
00043	MON1	EMER	EXTR	0800	37	4	2
00044	MON1	INTM	CHST	0800	42	3	4
00045	MON1	PEDS	SPIN	0800	51	3	9
00046	MON1	GOPC	EXTR	0800	57	2	11
00047	MON1	WD3E	CHST	0900	1	4	6
00048	MON1	USDB	EXTR	0800	78	5	0
00049	MON1	GOPC	CHST	0800	89	2	5
00050	MON1	MEDX	CHST	0800	83	2	1
00051	MON1	GOPC	CHST	0800	78	4	9
00052	MON1	ORTH	EXTR	0800	92	1	1
00053	MON1	EMER	EXTR	0800	64	2	17
00054	MON1	GOPC	EXTR	0800	82	5	9
00055	MON1	GOPC	EXTR	0800	92	7	5
00056	MON1	GOPC	EXTR	0900	83	9	5
00057	MON1	EMER	EXTR	0900	101	3	0
00058	MON1	GOPC	EXTR	0900	107	2	2
00059	MON1	PEDS	EXTR	0900	80	3	11
00060	MON1	GOPC	SPIN	0900	93	14	4
00061	MON1	GOPC	EXTR	1000	81	3	0
00062	MON1	GOPC	EXTR	1000	75	16	0
00063	MON1	PEDS	EXTR	1000	80	17	0
00064	MON1	WD3B	CHST	1100	70	4	6
00065	MON1	WD3B	IVP	1200	20	55	0
00066	MON1	INTM	CHST	1100	119	5	5
00067	MON1	GOPC	EXTR	1200	77	5	1
00068	MON1	ORTH	EXTR	1200	86	4	20
00069	MON1	ORTH	EXTR	1200	110	4	1
00070	MON1	EMER	CHST	1200	81	2	1
00071	MON1	FAMP	EXTR	1200	82	1	6
00072	MON1	EMER	EXTR	1200	68	5	0
00073	MON1	WD3B	EXTR	1300	13	6	11
00074	MON1	GOPC	EXTR	1300	31	3	0
00075	MON1	INTM	CHST	1400	19	5	6
00076	MON1	PEDS	EXTR	1400	25	3	0
00077	MON1	FAMP	EXTR	1400	18	3	3
00078	MON1	PEDS	EXTR	1400	8	4	35
00079	MON1	ORTH	EXTR	1500	35	8	2
00080	MON1	GOPC	HEAD	1500	42	10	1
00081	MON1	GOPC	EXTR	1500	47	10	9
00082	MON1	INTM	CHST	1500	64	3	0
00083	MON1	ORTH	EXTR	1500	57	2	0
00084	MON1	ORTH	EXTR	1500	49	3	4
00085	MON1	GOPC	EXTR	1600	43	3	8
00086	MON1	WD3B	MULT	1600	35	8	1
00087	MON1	EMER	EXTR	1600	37	4	0

LIST FOR DAY='TUE1'

00088	TUE1	ORTH	CHST	0800	15	2	5
00089	TUE1	ORTH	EXTR	0800	15	4	4
00090	TUE1	ORTH	EXTR	0800	28	4	1
00091	TUE1	FAMP	EXTR	0800	33	10	4
00092	TUE1	INTM	KUB	0800	29	5	5
00093	TUE1	GOPC	EXTR	0800	26	3	2
00094	TUE1	ORTH	EXTR	0800	19	6	8
00095	TUE1	MEDX	CHST	0800	25	2	3
00096	TUE1	FT	EXTR	0800	31	4	1
00097	TUE1	MEDX	CHST	0800	29	2	15
00098	TUE1	FAMP	EXTR	0900	45	2	3
00099	TUE1	GOPC	SPIN	0900	39	10	15
00100	TUE1	GOPC	UGI	0900	45	20	10
00101	TUE1	GOPC	SPIN	0900	84	25	15
00102	TUE1	GOPC	UGI	1000	75	25	2
00103	TUE1	MEDX	CHST	0900	154	1	13
00104	TUE1	MEDX	CHST	0900	131	2	2
00105	TUE1	GOPC	CHST	0900	154	1	0
00106	TUE1	GOPC	SPIN	0900	157	3	2
00107	TUE1	FAMP	CHST	0900	165	3	9
00108	TUE1	MEDX	MULT	1000	131	12	7
00109	TUE1	ORTH	EXTR	1000	122	4	2
00110	TUE1	PEDS	ABD	1000	125	2	20
00111	TUE1	EMER	HEAD	1000	145	15	2
00112	TUE1	GOPC	SPIN	1100	108	6	3
00113	TUE1	INTM	CHST	1100	139	3	3
00114	TUE1	ORTH	SPIN	1300	25	3	0
00115	TUE1	ORTH	SPIN	1300	10	15	7
00116	TUE1	GOPC	EXTR	0900	160	6	12
00117	TUE1	FAMP	EXTR	1000	120	15	5
00118	TUE1	GOPC	EXTR	1300	80	5	23
00119	TUE1	GOPC	CHST	1400	69	3	4
00120	TUE1	GOPC	EXTR	1400	71	2	1
00121	TUE1	GOPC	EXTR	1500	8	3	2
00122	TUE1	INTM	CHST	1000	120	3	8
00123	TUE1	MENT	CHST	1400	29	3	1
00124	TUE1	EMER	CHST	1500	42	2	6
00125	TUE1	ORTH	EXTR	1500	36	6	13
00126	TUE1	GOPC	HEAD	1000	158	5	2
00127	TUE1	FAMP	EXTR	1600	29	3	0

## LIST FOR DAY='WED1'

00128	WED1	PEDS	SPIN	0800	2	6	7
00129	WED1	MEDX	CHST	0800	14	2	3
00130	WED1	PEDS	EXTR	0800	15	8	4
00131	WED1	MEDX	CHST	0800	28	2	13
00132	WED1	MEDX	CHST	0800	20	2	2
00133	WED1	FAMP	EXTR	0800	23	4	10
00134	WED1	WD2B	UGI	0800	40	33	1
00135	WED1	MEDX	CHST	0800	85	4	1
00136	WED1	GOFC	EXTR	0800	73	3	3
00137	WED1	MEDX	CHST	0800	77	4	6
00138	WED1	INTM	BE	0900	29	55	0
00139	WED1	FAMP	EXTR	0800	157	6	1
00140	WED1	MEDX	CHST	0800	126	4	2
00141	WED1	INTM	CHST	0800	137	3	2
00142	WED1	GOFC	EXTR	0900	132	4	3
00143	WED1	OBGY	IVP	1000	65	35	14
00144	WED1	MEDX	SP N	0900	158	3	11
00145	WED1	GOFC	CHST	0900	139	2	2
00146	WED1	PEDS	CHST	1000	101	6	4
00147	WED1	GOFC	SPIN	1000	107	15	3
00148	WED1	ORTH	EXTR	1000	105	3	8
00149	WED1	FAMP	EXTR	1100	114	2	0
00150	WED1	FAMP	SPIN	1100	86	20	5
00151	WED1	ORTH	EXTR	1100	94	2	1
00152	WED1	GOFC	CHST	1100	100	4	8
00153	WED1	EMER	EXTR	1200	94	4	0
00154	WED1	FAMP	EXTR	1200	93	5	23
00155	WED1	EMER	HEAD	1300	15	27	4
00156	WED1	FAMP	CHST	1200	143	4	2
00157	WED1	GOFC	CHST	1300	105	2	2
00158	WED1	FAMP	KUB	1300	69	2	7
00159	WED1	GOFC	EXTR	1300	71	6	2
00160	WED1	FAMP	CHST	1300	68	2	11
00161	WED1	GOFC	SPIN	1400	41	4	1
00162	WED1	INTM	CHST	1400	34	2	10
00163	WED1	FAMP	CHST	1500	28	3	1
00164	WED1	GOFC	CHST	1500	28	2	11
00165	WED1	WD2C	CHST	1500	18	3	11
00166	WED1	EMER	EXTR	1500	30	28	4
00167	WED1	FAMP	EXTR	1500	60	4	2
00168	WED1	FAMP	SPIN	1500	59	8	2
00169	WED1	GOFC	MULT	1500	66	9	1
00170	WED1	EMER	SPIN	1500	73	8	0



LIST FOR DAY='THU1'

00171	THU1	INTM	SPIN	0800	18	26	4
00172	THU1	ORTH	EXTR	0800	48	2	1
00173	THU1	ORTH	EXTR	0800	51	3	6
00174	THU1	GOFC	EXTR	0800	41	2	22
00175	THU1	GOFC	SPIN	0800	65	9	2
00176	THU1	INTM	UGI	0800	73	40	5
00177	THU1	MEDX	CHST	0800	117	1	1
00178	THU1	MEDX	CHST	0800	114	2	1
00179	THU1	MEDX	SPIN	0900	85	3	4
00180	THU1	WD3B	IVP	1000	15	52	5
00181	THU1	INTM	CHST	0900	98	2	1
00182	THU1	GOFC	SPIN	0900	148	21	2
00183	THU1	ORTH	EXTR	0900	108	1	0
00184	THU1	FAMP	CHST	0900	152	2	6
00185	THU1	ORTH	EXTR	1100	85	14	0
00186	THU1	FAMP	EXTR	0900	155	3	4
00187	THU1	EMER	EXTR	1200	19	15	2
00188	THU1	GOFC	EXTR	1000	167	4	8
00189	THU1	FAMP	EXTR	0900	170	4	3
00190	THU1	MEDX	EXTR	1000	164	2	2
00191	THU1	ORTH	EXTR	1000	161	5	3
00192	THU1	ORTH	EXTR	1000	163	3	2
00193	THU1	ORTH	EXTR	1000	164	4	10
00194	THU1	GOFC	CHST	1000	169	7	1
00195	THU1	GOFC	EXTR	1000	169	7	3
00196	THU1	ORTH	EXTR	0900	150	6	0
00197	THU1	ORTH	EXTR	1100	144	4	6
00198	THU1	EMER	SPIN	1100	145	5	0
00199	THU1	GOFC	SPIN	1100	139	8	4
00200	THU1	ORTH	EXTR	1100	168	5	5
00201	THU1	ORTH	EXTR	1200	115	6	13
00202	THU1	ORTH	EXTR	1100	177	2	1
00203	THU1	FAMP	CHST	1400	20	4	0
00204	THU1	ORTH	EXTR	1300	60	11	13
00205	THU1	FAMP	CHST	1400	68	5	1
00206	THU1	EMER	EXTR	1400	30	6	5
00207	THU1	FAMP	EXTR	1000	155	4	1
00208	THU1	EMER	EXTR	1200	150	3	6
00209	THU1	FAMP	CHST	1500	6	11	?
00210	THU1	ORTH	EXTR	1600	10	4	1
00211	THU1	GOFC	CHST	1700	15	2	5
00212	THU1	GOFC	EXTR	1600	13	2	1
00213	THU1	GOFC	EXTR	1600	5	4	0

## LIST FOR DAY='FRI2'

00214	FRI2	GOFC	IVP	0800	9	35	5
00215	FRI2	PEDS	IVP	0800	21	45	8
00216	FRI2	FAMP	CHST	0800	108	5	1
00217	FRI2	PEDS	SPIN	0800	115	2	0
00218	FRI2	FAMP	SPIN	0800	116	4	10
00219	FRI2	FAMP	CHST	0800	129	4	0
00220	FRI2	ORTH	EXTR	0800	131	3	1
00221	FRI2	EMER	EXTR	0800	137	4	4
00222	FRI2	FAMP	EXTR	0800	143	1	2
00223	FRI2	ORTH	EXTR	0900	88	1	1
00224	FRI2	GOFC	CHST	0900	81	2	1
00225	FRI2	PEDS	EXTR	0900	81	5	1
00226	FRI2	GOFC	MULT	0900	84	6	7
00227	FRI2	PEDS	EXTR	1000	42	2	2
00228	FRI2	EMER	EXTR	1000	45	2	7
00229	FRI2	PEDS	CHST	0900	94	4	6
00230	FRI2	USDB	EXTR	1000	25	2	1
00231	FRI2	USDB	CHST	1000	28	1	1
00232	FRI2	USDB	HEAD	1000	31	9	7
00233	FRI2	GOFC	EXTR	1000	75	3	1
00234	FRI2	FAMP	CHST	1000	78	5	5
00235	FRI2	PEDS	EXTR	1000	60	2	2
00236	FRI2	INTM	EXTR	1000	56	3	3
00237	FRI2	PT	EXTR	1100	43	4	2
00238	FRI2	SURG	CHST	1100	57	3	7
00239	FRI2	FAMP	EXTR	1100	45	2	1
00240	FRI2	FAMP	CHST	1100	47	7	1
00241	FRI2	FAMP	CHST	1100	36	1	7
00242	FRI2	ORTH	EXTR	1200	21	3	9
00243	FRI2	WDDB	EXTR	1200	8	2	5
00244	FRI2	EMER	EXTR	1200	5	3	9
00245	FRI2	ALBY	MULT	0800	88	17	7
00246	FRI2	INTM	CHST	1400	7	16	3
00247	FRI2	GOFC	SPIN	1400	45	14	6
00248	FRI2	EMER	SPIN	1400	39	28	0
00249	FRI2	EMER	SPIN	1400	73	3	6
00250	FRI2	GOFC	EXTR	1500	31	2	1
00251	FRI2	FAMP	SPIN	1500	22	10	8
00252	FRI2	EMER	EXTR	1500	38	4	0
00253	FRI2	GOFC	EXTR	1600	23	4	0

LIST FOR DAY='MON2'

00254	MON2	FAMP	SPIN	0800	11	19	1
00255	MON2	MEDX	CHST	0800	30	3	1
00256	MON2	MEDX	CHST	0800	35	1	10
00257	MON2	GOFC	HEAD	0800	36	4	2
00258	MON2	ORTH	EXTR	0800	25	17	6
00259	MON2	MEDX	CHST	0800	37	2	5
00260	MON2	ORTH	EXTR	0800	36	5	3
00261	MON2	MEDX	CHST	0800	44	2	1
00262	MON2	INTM	IVP	0900	32	77	1
00263	MON2	ORTH	EXTR	1000	31	1	10
00264	MON2	WD3B	CHST	1000	12	2	1
00265	MON2	OBGY	IVP	1000	58	25	9
00266	MON2	INTM	HEAD	1000	49	5	1
00267	MON2	ORTH	EXTR	1100	35	3	37
00268	MON2	WD3B	BE	1200	5	25	3
00269	MON2	EMER	SPIN	1100	88	7	1
00270	MON2	EMER	CHST	1300	1	3	+
00271	MON2	INTM	MULT	1100	105	4	0
00272	MON2	ORTH	EXTR	1100	83	3	3
00273	MON2	GOFC	HEAD	1200	66	10	4
00274	MON2	ORTH	EXTR	1200	74	10	2
00275	MON2	EMER	HEAD	1300	12	7	0
00276	MON2	FAMP	CHST	1300	10	3	1
00277	MON2	FAMP	MULT	1300	8	16	0
00278	MON2	MEDX	EXTR	1400	9	8	13
00279	MON2	WD3B	BE	1400	0	58	0
00280	MON2	GOFC	CHST	1400	41	10	17
00281	MON2	ORTH	EXTR	1400	63	2	1
00282	MON2	WD3B	CHST	1500	60	2	0
00283	MON2	MEDX	EXTR	1600	0	6	0

LIST FOR DAY='TUE2'

00284	TUE2	INTM	EXTR	0800	7	1	0
00285	TUE2	MEDX	CHST	0800	6	3	4
00286	TUE2	ORTH	EXTR	0800	3	4	1
00287	TUE2	MEDX	CHST	0800	5	1	6
00288	TUE2	WD2B	CHST	0800	30	4	5
00289	TUE2	PT	EXTR	0800	2	5	8
00290	TUE2	FAMP	EXTR	0800	13	6	3
00291	TUE2	MEDX	CHST	0800	29	2	6
00292	TUE2	EMER	CHST	0900	6	4	3
00293	TUE2	GOFC	EXTR	0900	13	7	7
00294	TUE2	INTM	RE	0900	16	51	2
00295	TUE2	ORTH	EXTR	0900	62	4	0
00296	TUE2	GOFC	UGI	0900	62	30	2
00297	TUE2	MEDX	CHST	0900	107	4	1
00298	TUE2	ORTH	EXTR	0900	96	3	4
00299	TUE2	INTM	EXTR	0900	98	7	2
00300	TUE2	INTM	EXTR	0900	100	23	0
00301	TUE2	ORTH	EXTR	1100	46	10	2
00302	TUE2	MEDX	CHST	1000	112	3	1
00303	TUE2	ORTH	SPIN	1000	95	13	1
00304	TUE2	ORTH	EXTR	1000	97	5	2
00305	TUE2	MEDX	CHST	1000	124	2	0
00306	TUE2	ORTH	EXTR	1000	103	4	13
00307	TUE2	ORTH	SPIN	1000	104	14	1
00308	TUE2	GOFC	CHST	1100	103	9	13
00309	TUE2	FEDS	SPIN	1100	123	3	3
00310	TUE2	GOFC	SPIN	1100	122	4	1
00311	TUE2	ORTH	EXTR	1200	84	1	8
00312	TUE2	GOFC	CHST	1200	83	4	1
00313	TUE2	FAMP	EXTR	1200	89	3	2
00314	TUE2	INTM	CHST	1200	77	3	2
00315	TUE2	ORTH	EXTR	1200	103	2	5
00316	TUE2	GOFC	CHST	1300	31	0	1
00317	TUE2	EMER	EXTR	1200	74	4	0
00318	TUE2	ORTH	EXTR	1300	25	1	1
00319	TUE2	FAMP	SPIN	1300	30	3	1
00320	TUE2	GOFC	CHST	1300	17	3	1
00321	TUE2	ORTH	EXTR	1400	14	3	8
00322	TUE2	EMER	EXTR	1400	27	9	1
00323	TUE2	INTM	SPIN	1400	25	15	1
00324	TUE2	MEDX	CHST	1400	28	1	6
00325	TUE2	ORTH	EXTR	1400	29	3	4
00326	TUE2	ORTH	HEAD	1500	16	15	7
00327	TUE2	GOFC	EXTR	1500	38	5	7
00328	TUE2	GOFC	CHST	1500	58	4	9
00329	TUE2	GOFC	MULT	1500	63	8	1
00330	TUE2	GOFC	EXTR	1500	53	2	15
00331	TUE2	EMER	EXTR	1500	77	4	6
00332	TUE2	ORTH	EXTR	1500	68	3	1
00333	TUE2	GOFC	HEAD	1500	82	15	1
00334	TUE2	EMER	SPIN	1600	46	9	0

LIST FOR DAY='WED2'

00335	WED2	EMER	EXTR	0800	1	2	16
00336	WED2	DRTH	EXTR	0800	16	1	12
00337	WED2	DRTH	EXTR	0800	12	2	3
00338	WED2	MEDX	CHST	0900	9	1	2
00339	WED2	OBSY	IVP	0900	2	50	0
00340	WED2	FAMP	IVP	1000	0	40	0
00341	WED2	GOFC	SPIN	0900	47	10	0
00342	WED2	INTM	CHST	1000	28	10	18
00343	WED2	PEDS	EXTR	1100	18	3	1
00344	WED2	GOFC	CHST	1100	16	3	0
00345	WED2	GOFC	EXTR	0900	55	2	3
00346	WED2	GOFC	SPIN	1100	21	5	1
00347	WED2	GOFC	CHST	1200	1	3	8
00348	WED2	FAMP	EXTR	1200	9	3	10
00349	WED2	EMER	SPIN	1300	10	15	0
00350	WED2	INTM	CHST	1300	7	10	3
00351	WED2	GOFC	SPIN	1300	12	8	9
00352	WED2	GOFC	CHST	1300	8	3	0
00353	WED2	FAMP	CHST	1300	24	1	4
00354	WED2	WD2C	SPEC	1400	4	84	5
00355	WED2	MEDX	CHST	1400	61	2	1
00356	WED2	EMER	CHST	1400	51	2	1
00357	WED2	GBGY	CHST	1400	54	1	3
00358	WED2	DRTH	EXTR	1500	48	3	1
00359	WED2	FAMP	KUB	1500	52	7	3
00360	WED2	DRTH	EXTR	1600	13	4	10
00361	WED2	GOFC	EXTR	1600	10	5	0

LIST FOR DAY='THU2'

00362	THU2	GOFC	EXTR	0800	15	3	9
00363	THU2	MEDX	CHST	0800	9	2	8
00364	THU2	GOFC	EXTR	0800	8	14	0
00365	THU2	MEDX	CHST	0800	17	1	0
00366	THU2	GOFC	CHST	0800	14	10	0
00367	THU2	ORTH	EXTR	0800	23	10	1
00368	THU2	GOFC	EXTR	0800	27	4	0
00369	THU2	GOFC	CHST	0900	20	2	8
00370	THU2	WD2C	SPEC	0900	2	69	0
00371	THU2	GOFC	SPIN	0900	55	20	1
00372	THU2	ORTH	EXTR	0900	103	6	0
00373	THU2	GOFC	EXTR	0900	105	2	2
00374	THU2	MEDX	CHST	0900	52	2	1
00375	THU2	FAMP	EXTR	0900	114	2	3
00376	THU2	GOFC	EXTR	0900	109	6	13
00377	THU2	INTM	HEAD	0900	106	8	12
00378	THU2	GOFC	SPIN	1000	115	2	1
00379	THU2	GOFC	CHST	1000	107	3	3
00380	THU2	ORTH	EXTR	1000	98	3	3
00381	THU2	ORTH	HEAD	1000	91	4	1
00382	THU2	INTM	CHST	1000	88	2	3
00383	THU2	ORTH	EXTR	1100	85	3	3
00384	THU2	EMER	EXTR	1100	68	3	4
00385	THU2	ORTH	EXTR	1100	76	2	5
00386	THU2	ORTH	EXTR	1100	57	10	6
00387	THU2	FAMP	SPIN	1100	73	17	1
00388	THU2	ORTH	EXTR	1200	82	10	1
00389	THU2	ORTH	EXTR	1200	87	1	2
00390	THU2	GOFC	EXTR	1100	88	3	2
00391	THU2	FAMP	CHST	1200	72	6	1
00392	THU2	INTM	SPIN	1300	49	11	1
00393	THU2	GOFC	EXTR	1300	25	4	11
00394	THU2	ORTH	EXTR	1400	11	10	10
00395	THU2	MEDX	EXTI	1400	15	5	2
00396	THU2	ORTH	EXTR	1400	20	1	7
00397	THU2	FAMP	HEAD	1500	7	8	0
00398	THU2	GOFC	EXTR	0900	100	4	0
00399	THU2	WD3B	CHST	1500	1	2	5
00400	THU2	ORTH	EXTR	1600	5	10	0
. LIST FOR DAY='FRI3'							
00401	FRI3	ORTH	SPIN	0800	5	9	5
00402	FRI3	INTM	UGI	0800	17	20	10
00403	FRI3	EMER	CHST	0900	36	3	2
00404	FRI3	GOFC	CHST	0800	35	2	8
00405	FRI3	INTM	IVF	0800	44	28	1
00406	FRI3	WD3B	CHST	0900	2	3	0

. LIST FOR DAY='MON3'

00407	MON3	MEDX	EXTR	0800	4	3	14
00408	MON3	EMER	EXTR	0800	12	4	17
00409	MON3	SURG	CHST	0800	35	1	3
00410	MON3	GOFC	EXTR	0800	36	3	6
00411	MON3	USDB	EXTR	0800	40	2	1
00412	MON3	USDB	SPIN	0800	43	2	4
00413	MON3	USDB	HEAD	0800	49	5	9
00414	MON3	GOFC	CHST	0800	63	2	3
00415	MON3	GOFC	CHST	0800	66	2	5
00416	MON3	FAMP	UGI	0800	70	30	8
00417	MON3	MEDX	CHST	0800	101	2	1
00418	MON3	MEDX	EXTR	0800	96	4	3
00419	MON3	ORTH	EXTR	0800	98	2	4
00420	MON3	INTM	CHST	0900	75	2	1
00421	MON3	GOFC	SPIN	0800	97	3	1
00422	MON3	GOFC	BE	1000	19	44	14
00423	MON3	ORTH	EXTR	0900	118	4	10
00424	MON3	ORTH	EXTR	0900	156	3	10
00425	MON3	MEDX	CHST	0900	130	1	1
00426	MON3	MEDX	CHST	0900	112	2	3
00427	MON3	MEDX	EXTR	1000	115	2	5
00428	MON3	ORTH	EXTR	1000	116	4	4
00429	MON3	GOFC	CHST	1000	100	2	4
00430	MON3	MEDX	CHST	1000	120	4	16
00431	MON3	MEDX	CHST	1100	63	2	6
00432	MON3	ORTH	EXTR	1100	96	4	6
00433	MON3	ORTH	EXTR	1000	133	16	4
00434	MON3	ORTH	EXTR	1200	76	1	1
00435	MON3	GOFC	CHST	1200	80	3	4
00436	MON3	EMER	EXTR	1200	66	6	0
00437	MON3	FAMP	SPIN	1200	63	7	12
00438	MON3	GOFC	EXTR	1300	54	3	7
00439	MON3	GOFC	CHST	1300	54	3	0
00440	MON3	GOFC	EXTR	1300	56	15	5
00441	MON3	OBGY	FLUR	1300	68	45	15
00442	MON3	WD3B	BE	1500	35	53	0
00443	MON3	GOFC	SPIN	1400	103	6	10
00444	MON3	WD3B	CHST	1500	59	4	3
00445	MON3	GOFC	MULT	1200	65	10	0
00446	MON3	WD2C	EXTR	1500	76	4	0

## LIST FOR DAY='TUE3'

00447	TUE3	GOFC	HEAD	0800	3	14	1
00448	TUE3	ORTH	EXTR	0800	13	5	1
00449	TUE3	ORTH	EXTR	0800	19	15	0
00450	TUE3	MEDX	CHST	0800	32	3	1
00451	TUE3	MEDX	CHST	0800	35	2	1
00452	TUE3	ORTH	EXTR	0800	30	5	1
00453	TUE3	GOFC	EXTR	0800	27	6	1
00454	TUE3	EMER	EXTR	0900	7	5	2
00455	TUE3	COMH	EXTR	0800	22	4	2
00456	TUE3	GOFC	EXTR	0800	31	4	4
00457	TUE3	GOFC	EXTR	0900	27	6	5
00458	TUE3	COMH	CHST	0900	34	3	6
00459	TUE3	ORTH	EXTR	0900	33	2	4
00460	TUE3	FAMP	EXTR	0900	17	3	2
00461	TUE3	MEDX	CHST	0900	19	1	11
00462	TUE3	GOFC	BE	1000	14	44	1
00463	TUE3	FAMP	HEAD	1000	57	8	2
00464	TUE3	EMER	EXTR	1100	2	15	3
00465	TUE3	ORTH	EXTR	1000	82	4	3
00466	TUE3	ORTH	SPIN	1000	84	12	5
00467	TUE3	EMER	EXTR	1000	99	2	1
00468	TUE3	GOFC	SPIN	1000	100	3	1
00469	TUE3	MEDX	CHST	1000	102	1	2
00470	TUE3	MEDX	CHST	1000	109	1	1
00471	TUE3	ORTH	EXTR	1000	109	8	5
00472	TUE3	ORTH	MULT	1000	117	31	0
00473	TUE3	ORTH	EXTR	1000	140	2	7
00474	TUE3	ORTH	EXTR	1000	146	2	2
00475	TUE3	ORTH	EXTR	1000	147	2	2
00476	TUE3	EMER	CHST	1100	108	3	1
00477	TUE3	GOFC	MULT	1100	112	13	0
00478	TUE3	FAMP	SPIN	1200	71	10	10
00479	TUE3	ORTH	XCRD	1300	25	60	5
00480	TUE3	EMER	KUB	1200	144	10	1
00481	TUE3	COMH	CHST	1200	154	4	5
00482	TUE3	GOFC	CHST	1200	142	7	8
00483	TUE3	USDB	TOMO	1300	107	55	2
00484	TUE3	ORTH	EXTR	1400	111	4	0
00485	TUE3	ORTH	MULT	1400	132	10	3
00486	TUE3	INTM	CHST	1400	115	3	0
00487	TUE3	INTM	EXTR	1400	132	4	3
00488	TUE3	ORTH	EXTR	1400	153	11	0
00489	TUE3	INTM	SPEC	1400	126	35	0



LIST FOR DAY='WED3'

00490	WED3	MEDX	CHST	0800	10	3	0
00491	WED3	ORTH	SPIN	0800	13	4	5
00492	WED3	FAMP	CHST	0800	20	2	0
00493	WED3	EENT	HEAD	0800	12	6	4
00494	WED3	ORTH	EXTR	0800	14	3	7
00495	WED3	GOFC	EXTR	0800	19	2	1
00496	WED3	OBGY	CHST	0800	25	2	1
00497	WED3	GOFC	EXTR	0800	17	2	1
00498	WED3	GOFC	EXTR	0800	17	5	9
00499	WED3	EMER	EXTR	0900	9	2	0
00500	WED3	EMER	EXTR	0900	11	4	0
00501	WED3	GOFC	UGI	0900	10	30	22
00502	WED3	GOFC	EXTR	1000	3	6	29
00503	WED3	GOFC	UGI	0900	65	20	4
00504	WED3	FAMP	EXTR	1000	33	2	7
00505	WED3	FAMP	SPIN	1100	7	6	11
00506	WED3	PEDS	SPIN	1100	24	7	14
00507	WED3	GOFC	CHST	1200	22	2	1
00508	WED3	GOFC	CHST	1200	29	5	7
00509	WED3	GOFC	CHST	1200	33	2	2
00510	WED3	EMER	SPIN	1200	35	36	7
00511	WED3	INTM	CHST	1200	42	3	1
00512	WED3	COMH	CHST	1300	29	2	11
00513	WED3	MEDX	CHST	1300	26	11	0
00514	WED3	EMER	HEAD	1300	33	25	5
00515	WED3	OBGY	IVP	1400	13	30	12
00516	WED3	ORTH	EXTR	1300	82	6	5
00517	WED3	GOFC	EXTR	1300	92	3	1
00518	WED3	ORTH	EXTR	1400	69	3	2
00519	WED3	FAMP	CHST	1400	75	2	1
00520	WED3	ORTH	EXTR	1400	79	4	1
00521	WED3	ORTH	EXTR	1400	83	3	2
00522	WED3	ORTH	EXTR	1500	38	5	9
00523	WED3	GOFC	CHST	1500	30	1	0
00524	WED3	SURG	CHST	1500	26	1	3
00525	WED3	ORTH	EXTR	1500	9	9	0
00526	WED3	PEDS	SPIN	1500	6	15	0

LIST FOR DAY='THU3'

00527	THU3	FAMP	SPIN	0800	5	15	9
00528	THU3	INTM	CHST	0800	6	11	17
00529	THU3	FAMP	CHST	0800	12	4	6
00530	THU3	ORTH	SPIN	0900	5	16	0
00531	THU3	ORTH	EXTR	0900	22	4	1
00532	THU3	FAMP	EXTR	0900	20	2	5
00533	THU3	OBGY	IVP	0900	29	44	5
00534	THU3	EMER	CHST	0900	62	11	2
00535	THU3	GOPC	EXTR	0900	72	6	4
00536	THU3	ORTH	SPIN	0900	70	11	1
00537	THU3	ORTH	EXTR	0900	80	3	0
00538	THU3	GOPC	EXTR	1000	58	5	2
00539	THU3	ORTH	EXTR	1000	56	3	0
00540	THU3	FAMP	CHST	1000	58	3	1
00541	THU3	GOPC	EXTR	1000	36	2	3
00542	THU3	WD3B	SPIN	1000	64	6	1
00543	THU3	ORTH	EXTR	1100	28	7	1
00544	THU3	FAMP	CHST	1100	35	3	0
00545	THU3	ORTH	EXTR	1100	37	4	4
00546	THU3	FAMP	CHST	1100	39	2	1
00547	THU3	FAMP	MULT	1100	36	32	0
00548	THU3	ORTH	EXTR	1100	61	5	5
00549	THU3	FAMP	CHST	1200	27	2	1
00550	THU3	EMER	EXTR	1200	20	4	4
00551	THU3	WD3B	BE	1200	9	51	6
00552	THU3	PEDS	CHST	1200	83	3	1
00553	THU3	INTM	CHST	1300	40	2	6
00554	THU3	USDB	EXTR	1300	28	3	14
00555	THU3	FAMP	EXTR	1300	26	5	0
00556	THU3	ORTH	EXTR	1300	30	10	2
00557	THU3	ORTH	EXTR	1300	35	8	7
00558	THU3	ORTH	EXTR	1400	46	2	1
00559	THU3	ORTH	EXTR	1400	46	6	1
00560	THU3	ORTH	EXTR	1400	47	2	1
00561	THU3	ORTH	EXTR	1400	49	7	1
00562	THU3	GOPC	CHST	1400	43	4	2
00563	THU3	GOPC	ABD	1600	2	7	2
00564	THU3	EMER	SPIN	1600	2	10	0

LIST FOR DAY='FRI4'

00565	FRI4	FAMP	SPIN	0800	4	18	1
00566	FRI4	FAMP	SPIN	0800	23	18	4
00567	FRI4	DRTH	EXTR	0800	40	2	1
00568	FRI4	MEDX	CHST	0800	32	2	1
00569	FRI4	FT	SPIN	0800	39	28	0
00570	FRI4	USDB	CHST	0800	97	2	11
00571	FRI4	DRTH	EXTR	0800	103	5	2
00572	FRI4	GOFC	IVP	0900	75	43	2
00573	FRI4	PEDS	CHST	0800	105	3	1
00574	FRI4	GOFC	EXTR	0900	94	3	3
00575	FRI4	GOFC	HEAD	0800	130	5	1
00576	FRI4	DRTH	MULT	0900	101	10	1
00577	FRI4	EMER	EXTR	1000	97	2	2
00578	FRI4	FAMP	UGI	1000	110	35	2
00579	FRI4	FAMP	EXTR	1000	100	3	1
00580	FRI4	FAMP	SPIN	1100	95	12	9
00581	FRI4	DRTH	EXTR	1100	111	3	1
00582	FRI4	EMER	EXTR	1000	140	3	1
00583	FRI4	GOFC	HEAD	1100	95	5	9
00584	FRI4	GOFC	EXTR	1100	107	3	6
00585	FRI4	PEDS	HEAD	1100	110	4	1
00586	FRI4	GOFC	HEAD	1100	99	5	0
00587	FRI4	EMER	MULT	1300	18	10	5
00588	FRI4	PEDS	SPEC	1200	52	52	8
00589	FRI4	DBGY	IVP	1300	55	30	2
00590	FRI4	WD3B	CHST	1300	132	4	0
00591	FRI4	FAMP	EXTR	1100	175	3	1
00592	FRI4	GOFC	SPIN	1300	112	10	1
00593	FRI4	GOFC	EXTR	1300	121	3	1
00594	FRI4	GOFC	EXTR	1300	125	3	1
00595	FRI4	EMER	EXTR	1500	15	2	4
00596	FRI4	GOFC	EXTR	1400	100	2	3
00597	FRI4	PEDS	MULT	1500	39	50	0

LIST FOR DAY='MON4'

00598	MON4	ORTH	SFIN	0800	15	3	2
00599	MON4	FAMP	EXTR	0800	19	3	2
00600	MON4	GOPC	HEAD	0800	6	7	6
00601	MON4	ORTH	EXTR	0800	30	11	1
00602	MON4	ORTH	EXTR	0800	36	2	9
00603	MON4	WD2B	CHST	0800	38	3	2
00604	MON4	GOPC	ABD	0800	37	6	2
00605	MON4	COMH	CHST	0800	44	3	1
00606	MON4	ORTH	EXTR	0800	48	6	4
00607	MON4	GOPC	CHST	0800	57	5	0
00608	MON4	MEDX	CHST	0800	60	1	1
00609	MON4	GOPC	CHST	0800	55	2	6
00610	MON4	SURG	BE	0900	38	35	1
00611	MON4	MEDX	SFIN	1000	16	9	2
00612	MON4	GOPC	EXTR	0800	93	6	6
00613	MON4	MEDX	CHST	0800	112	1	1
00614	MON4	COMH	CHST	0900	103	3	1
00615	MON4	SURG	BE	1000	48	39	3
00616	MON4	EMER	EXTR	0900	121	6	1
00617	MON4	GOPC	EXTR	0900	127	5	2
00618	MON4	DENT	HEAD	0900	134	7	1
00619	MON4	GOPC	EXTR	0900	136	2	5
00620	MON4	SURG	BE	1100	31	30	2
00621	MON4	GOPC	SFIN	1100	146	11	1
00622	MON4	INTM	CHST	1000	123	2	1
00623	MON4	FAMP	EXTR	0900	164	6	1
00624	MON4	GOPC	EXTR	1100	83	2	8
00625	MON4	GOPC	CHST	1200	49	2	3
00626	MON4	GOPC	MULT	1200	46	5	1
00627	MON4	PT	SFIN	1200	43	5	6
00628	MON4	EMER	CHST	1300	7	2	6
00629	MON4	EMER	HEAD	1200	44	10	1
00630	MON4	SURG	SFIN	1200	64	2	6
00631	MON4	ORTH	EXTR	1300	44	2	1
00632	MON4	GOPC	EXTR	1300	24	2	6
00633	MON4	EMER	EXTR	1300	27	5	1
00634	MON4	ORTH	EXTR	1300	27	3	11
00635	MON4	DBGY	SPEC	1300	38	25	5
00636	MON4	GOPC	EXTR	1400	27	2	16
00637	MON4	GOPC	MULT	1400	19	20	4
00638	MON4	WD3B	SPEC	1500	6	35	0

LIST FOR DAY='TUE4'

00639	TUE4	WD3P	CHST	0800	5	9	1
00640	TUE4	ORTH	EXTR	0800	18	2	4
00641	TUE4	MEDX	CHST	0800	23	3	1
00642	TUE4	FAMP	EXTR	0800	23	3	11
00643	TUE4	DENT	HEAD	0800	22	6	4
00644	TUE4	ORTH	EXTR	0800	23	2	1
00645	TUE4	GOPC	EXTR	0800	23	2	6
00646	TUE4	GOPC	EXTR	0800	30	2	4
00647	TUE4	MEDX	CHST	0800	36	1	7
00648	TUE4	GOPC	EXTR	0800	40	16	18
00649	TUE4	INTM	BE	0900	38	27	8
00650	TUE4	INTM	CHST	0900	82	2	1
00651	TUE4	MEDX	CHST	0900	81	2	7
00652	TUE4	MEDX	IVP	1000	30	35	7
00653	TUE4	ORTH	EXTR	0900	125	3	1
00654	TUE4	GOPC	SPIN	0900	129	3	1
00655	TUE4	ORTH	EXTR	0900	126	5	5
00656	TUE4	EMER	EXTR	1000	60	4	1
00657	TUE4	MEDX	TOMD	1100	12	78	2
00658	TUE4	MEDX	CHST	0900	213	2	2
00659	TUE4	ORTH	EXTR	1000	142	2	0
00660	TUE4	ORTH	EXTR	1000	140	4	9
00661	TUE4	ORTH	EXTR	1100	129	2	2
00662	TUE4	INTM	CHST	1100	133	2	1
00663	TUE4	ORTH	EXTR	1100	136	2	2
00664	TUE4	GOPC	EXTR	1100	121	4	6
00665	TUE4	ORTH	EXTR	1100	129	1	0
00666	TUE4	PEDS	EXTR	1100	129	2	0
00667	TUE4	GOPC	CHST	1100	123	2	4
00668	TUE4	ORTH	MULT	1200	103	6	3
00669	TUE4	FAMP	SPIN	1200	107	20	5
00670	TUE4	ORTH	ARTH	1400	25	35	4
00671	TUE4	ORTH	EXTR	1200	154	3	4
00672	TUE4	WD2C	EXTR	1400	38	12	0
00673	TUE4	ALGY	HEAD	1500	18	4	1
00674	TUE4	EMER	EXTR	1500	18	4	3
00675	TUE4	GOPC	HEAD	1500	22	8	5
00676	TUE4	GOPC	EXTR	1500	18	8	2
00677	TUE4	GOPC	EXTR	1500	25	13	0

LIST FOR DAY='WED4'

00678	WED4	WD3B	CHST	0800	5	2	0
00679	WED4	MEDX	CHST	0800	7	3	1
00680	WED4	ORTH	EXTR	0800	9	3	1
00681	WED4	MEDX	CHST	0800	6	2	6
00682	WED4	MEDX	CHST	0800	6	5	1
00683	WED4	MEDX	CHST	0800	5	3	3
00684	WED4	INTM	SPIN	0800	3	8	3
00685	WED4	GOPC	CHST	0800	3	5	0
00686	WED4	GOPC	EXTR	0800	5	2	6
00687	WED4	MEDX	CHST	0900	6	1	0
00688	WED4	GOP	CHST	0900	6	1	3
00689	WED4	GOPC	EXTR	0900	3	5	27
00690	WED4	INTM	IVP	0900	29	27	1
00691	WED4	GOPC	EXTR	0900	48	4	0
00692	WED4	PEDS	EXTR	0900	48	5	1
00693	WED4	PEDS	EXTR	1000	30	9	0
00694	WED4	EMER	EXTR	1000	24	2	1
00695	WED4	GOPC	EXTR	1000	24	4	2
00696	WED4	FAMP	EXTR	1000	27	3	4
00697	WED4	FAMP	EXTR	1100	4	5	1
00698	WED4	EMER	CHST	1100	1	10	19
00699	WED4	ORTH	CHST	1100	23	2	1
00700	WED4	FAMP	EXTR	1100	16	3	45
00701	WED4	EMER	ABD	1100	91	60	2
00702	WED4	ORTH	EXTR	1300	51	8	2
00703	WED4	GOPC	CHST	1300	37	3	1
00704	WED4	GOPC	CHST	1300	34	3	8
00705	WED4	MEDX	SPIN	1300	26	15	4
00706	WED4	GOPC	EXTR	1400	31	8	3
00707	WED4	EMER	EXTR	1400	14	4	4
00708	WED4	GOPC	EXTR	1400	17	1	1
00709	WED4	EMER	EXTR	1400	15	3	2
00710	WED4	WD2C	CHST	1500	2	11	10
00711	WED4	GOPC	SPIN	1500	10	2	1
00712	WED4	INTM	EXTR	1500	11	4	8
00713	WED4	ORTH	EXTR	1500	11	6	4
00714	WED4	FAMP	SPIN	1500	4	21	1
00715	WED4	FAMP	EXTR	1500	20	13	0

LIST FOR DAY='THU4'

00716	THU4	MEDX	CHST	0800	12	4	2
00717	THU4	ORTH	EXTR	0800	18	8	0
00718	THU4	ORTH	EXTR	0800	24	7	2
00719	THU4	GOPC	SPIN	0800	32	4	1
00720	THU4	ORTH	EXTR	0800	30	5	1
00721	THU4	MEDX	CHST	0800	16	2	3
00722	THU4	PEDS	CHST	0800	18	4	8
00723	THU4	GOPC	EXTR	0800	16	9	7
00724	THU4	GOPC	EXTR	0900	9	3	14
00725	THU4	ORTH	TOMQ	0900	36	48	1
00726	THU4	ORTH	EXTR	0900	52	16	1
00727	THU4	INTM	CHST	0900	60	1	0
00728	THU4	ORTH	EXTR	0900	53	8	3
00729	THU4	ORTH	SPIN	1000	49	14	0
00730	THU4	EMER	HEAD	1000	49	8	1
00731	THU4	EMER	EXTR	1100	21	2	2
00732	THU4	ORTH	EXTR	1100	20	5	1
00733	THU4	MEDX	CHST	1100	24	2	12
00734	THU4	GOPC	EXTR	1100	9	2	6
00735	THU4	ORTH	EXTR	1200	6	6	4
00736	THU4	GOPC	EXTR	1200	4	7	6
00737	THU4	MEDX	EXTR	1200	14	6	24
00738	THU4	MEDX	CHST	1200	24	12	1
00739	THU4	ORTH	EXTR	1300	13	9	2
00740	THU4	ORTH	EXTR	1300	14	2	2
00741	THU4	GOPC	CHST	1300	13	2	3
00742	THU4	GOPC	EXTR	1300	4	4	2
00743	THU4	WD2C	EXTR	1300	1	7	7
00744	THU4	FAMP	CHST	1400	7	1	3
00745	THU4	ORTH	EXTR	1400	10	6	10
00746	THU4	ORTH	EXTR	1400	10	5	1
00747	THU4	ORTH	EXTR	1400	13	5	5
00748	THU4	ORTH	EXTR	1400	19	5	17
00749	THU4	EMER	SPIN	1500	17	7	2
00750	THU4	EMER	EXTR	1500	5	1	1
00751	THU4	MEDX	CHST	1600	1	3	0

APPENDIX E

ESTIMATE OF WORKLOAD EXPECTED DURING THE EMU

AVERAGE NUMBER OF EXAMINATIONS EXPECTED PER FOUR-WEEK PERIOD  
August 1986 - April 1987

Type of Examination	Aug-Oct	Nov-Jan	Feb-Apr
<b>General X-Ray:</b>			
Chest/Ribs	224	200	220
Extremities	360	300	329
Head/Sinus	36	43	43
Spine	80	76	90
Kidneys/Ureters/Bladder	9	9	8
Abdominal Series	10	10	11
Multiple	19	18	23
<b>Total</b>	<b>738</b>	<b>656</b>	<b>724</b>
<b>Fluoroscopic and Special</b>			
Upper Gastrointestinal	25	29	23
Barium Enema	29	20	19
Barium Swallow	3	4	2
Gall Bladder	5	5	5
Small Bowel Follow Through	3	2	1
Arthrogram	2	2	2
Venogram	2	2	1
Intravenous Pyelogram	17	18	21
Tomogram	3	2	3
Xerogram	-	1	1
Other	5	6	7
<b>Total</b>	<b>94</b>	<b>91</b>	<b>85</b>
<b>Mammograms</b>	<b>60</b>	<b>60</b>	<b>60</b>



APPENDIX F

ESTIMATE OF EXPECTED AVERAGE WAITING TIME  
ALTERNATE SCHEDULING METHOD #2

TABLE 20

EXPECTED DISTRIBUTION OF PATIENT ARRIVALS  
ALTERNATE SCHEDULING METHOD #2

Arrival Hour	General X-Rays	Sched. F&S	Unsched. F&S	Total F&S
0800	187	-	1	1
0900	105	-	3	3
1000	91	-	1	1
1100	81	-	2	2
1200	61	-	4	4
1300	66	4	1	5
1400	61	2	3	5
1500	63	-	2	2
1600	23	-	-	-
Total	738	6	17	23

TABLE 21

EXPECTED AVERAGE EXAMINATION COMPLETION TIMES  
AND CUMULATIVE VARIANCE FROM SERVICE CAPACITY  
ALTERNATE SCHEDULING METHOD #2

Arrival Hour	Average Daily Arrivals		Average Time Required to Complete Examinations (In minutes)			Cumulative Variance from Service Capacity (In minutes)
	Gen.	F&S	Gen.	F&S	Total	
0800	9.35	0.05	92	2	94	+34
0900	5.25	0.15	51	7	58	+32
1000	4.55	0.05	45	2	47	+19
1100	4.05	0.10	40	5	45	+4
1200	3.05	0.20	30	9	39	-17
1300	3.30	0.25	32	11	43	-34
1400	3.05	0.25	30	11	41	-53
1500	3.15	0.10	31	5	36	-77
1600	1.15	--	11	--	--	-96

TABLE 22

DIFFERENCES IN AVERAGE EXAMINATION COMPLETION TIMES REQUIRED  
ALTERNATE SCHEDULING METHOD #2  
(In Minutes)

Arrival Hour	Study Period (Observed)	Alternate Method #1 (Expected)	Difference	Cumulative Difference
0800	105	94	-11	-11
0900	83	58	-25	-36
1000	67	47	-20	-56
1100	43	45	+2	-54

TABLE 23

ESTIMATE OF EXPECTED AVERAGE WAITING TIMES  
ALTERNATE SCHEDULING METHOD #2  
(In Minutes)

Arrival Hour	Study Period Average Patient Waiting Time (Observed)	Cumulative Difference in Average Examination Completion Time (+ or -)	Expected Average Patient Waiting Time
0800	47	-11	36
0900	87	-36	51
1000	94	-56	38
1100	79	-54	25

APPENDIX G

OPTIMAL SOLUTION COMPUTER PRINTOUT  
ALTERNATE SCHEDULING METHOD #3

YOUR VARIABLES 1 THROUGH 10  
SLACK VARIABLES 11 THROUGH 22

ANSWERS:

PRIMAL VARIABLES:

VARIABLES	VALUE
1	33.31249
2	20
4	6.666666
6	2.666667
7	2.666667
8	20
9	1.333333
10	80
11	1030
13	3.015633
15	4
17	2

DUAL VARIABLES:

VARIABLE	VALUE
1	0
2	1.21875
3	0
4	30.29167
5	0
6	11.5
7	0
8	86.875
9	75.83333
10	73.54167
11	147.2083
12	31.25

VALUE OF OBJECTIVE FUNCTION 11019.19

APPENDIX H

OPTIMAL SOLUTION COMPUTER PRINTOUT  
ALTERNATE SCHEDULING METHOD #4

YOUR VARIABLES 1 THROUGH 10  
SLACK VARIABLES 11 THROUGH 22

ANSWERS:

PRIMAL VARIABLES:

VARIABLES	VALUE
1	7.06249
2	20
4	6.666667
6	2.666667
7	2.666667
8	20
9	1.333333
10	80
11	1030
13	22.70313
15	4
17	2

DUAL VARIABLES:

VARIABLE	VALUE
1	0
2	1.21875
3	0
4	30.29167
5	0
6	11.5
7	0
8	86.875
9	75.83333
10	73.54167
11	147.2083
12	31.25

VALUE OF OBJECTIVE FUNCTION 9995.438

APPENDIX I

OPTIMAL SOLUTION COMPUTER PRINTOUT  
 ALTERNATE SCHEDULING METHOD #3  
 (25% Workload Increase)

YOUR VARIABLES 1 THROUGH 10  
 SLACK VARIABLES 11 THROUGH 22

ANSWERS:

PRIMAL VARIABLES:

VARIABLES	VALUE
2	24.66666
6	4
7	4
8	25.33334
9	1.333333
10	100
11	1770
13	25
14	.5000046
15	5
16	6
17	3

DUAL VARIABLES:

VARIABLE	VALUE
1	0
2	1.702128
3	0
4	0
5	0
6	0
7	0
8	57.87235
9	37.16313
10	44.53902
11	113.0497
12	11.9149

VALUE OF OBJECTIVE FUNCTION 11993.33

APPENDIX J

OPTIMAL SOLUTION COMPUTER PRINTOUT  
 ALTERNATE SCHEDULING METHOD #4  
 (25% Workload Increase)

YOUR VARIABLES 1 THROUGH 10  
 SLACK VARIABLES 11 THROUGH 22

ANSWERS:

PRIMAL VARIABLES:

VARIABLES	VALUE
2	6.794323
6	4
7	4
8	25.33334
9	1.333333
10	100
11	1770
13	35
14	13.90426
15	5
16	6
17	3

DUAL VARIABLES:

VARIABLE	VALUE
1	0
2	1.702128
3	0
4	0
5	0
6	0
7	0
8	57.87235
9	37.16313
10	44.53902
11	113.0497
12	11.9149

VALUE OF OBJECTIVE FUNCTION 10563.55

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