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Pipeline Gathering System Operations Model

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ABSTRACT

A computer model to aid in the analysis of pipeline gathering system operations has been developed. The model simulates the actual daily operation of the gathering system, on a task by task basis, taking into account terrain, climate, and facility breakdowns. The model can be used to project operating requirements for new systems or analyze problems in existing systems.

INTRODUCTION

In the past, petroleum and natural gas companies had few major problems in gathering and transporting their products to market. Reservoirs were large and in most cases conveniently located in the continental United States. Reservoir pressures were high so that compression requirements were minimal, pipeline friction losses were not critical, and the number of operation and maintenance problems were few.

However, in recent times this picture has changed dramatically. Existing reservoirs are being depleted at an increasing rate, lowering reservoir pressures, and expanding compression, pipeline and treatment facility requirements. These facilities are not only more abundant but also must function under more severe operating conditions such as higher compression ratios, lower pipeline pressures, and more associated liquids and sulphur production. It is readily apparent that these two factors, more facilities and harsher operating conditions, spell an alarming increase in manpower, equipment, and capital to maintain and operate a gathering system at production levels at or even below those of the past.

Furthermore, the increasing value of petroleum and natural gas due to scarcity and demand has spurred exploration in remote areas. Many firms are realizing that not only are capital costs higher for facilities in these areas, but operation and maintenance costs can greatly exceed those of conventional production areas. This higher cost is often due to such things as lower quality reservoirs, geographic location, surface terrain, and climatic conditions, to name a few. Therefore, a procedure must be developed to project operating and maintenance costs and requirements for these areas as well as existing gathering systems in order to adequetely evaluate new production opportunities on a timely basis.

THE PROBLEM

The evaluation of operating requirements for a new system or an existing system expansion should be included in the initial project feasibility study. The continual addition of marginal fields with intensive operating characteristics will eventually result in burdensome operating costs and leave a firm without the production flexibility needed to react in today's dynamic energy environment.

Estimating operating resource requirements by extrapolating from an existing system will often produce unsound estimates due to the inherent differences between any two gathering systems, especially in new or proposed areas. Various departments within a company may have no choice but to use their own algorithms for estimating operating requirements due to the amount of detail needed and lead time available. Furthermore, the analysis and improvement of existing system operations is a constant concern.

In response, the Pipeline Gathering System Operations Model has been constructed to aid the:

(1) Identification of system components and parameters having a significant effect on gathering system

operation and maintenance requirements,

(2) Prediction of manpower, vehicle, and equipment requirements for new or expanding gathering systems,
(3) Estimation of operating costs for a proposed or expanding gathering system,
(4) Prediction of the seasonal variation in work backlog,
(5) Evaluation of the effects of changes in crew size and make-up on system operations and overtime requirements,
(6) Determination of the feasibility of automating certain types of field facilities,
(7) Evaluation of alternative task scheduling techniques.

Accordingly, the model may be set-up to function in a new system operating requirements mode or an existing system analysis mode.

MODEL CONSTRUCTION

The model was constructed using a micro-analysis approach, one that begins at the basic man-machine interaction level in building an overall system model.[1, 3] The construction of this model was based on Mize and Cox's premise that most man-machine systems can be described in terms of the following features:

(1) Components,
(2) Variables (external and internal),
(3) Parameters,
(4) Relationships (among the above).[2]

Components can be individually identified and their performance determines the requirements of the system. In this study they consist of the operating office, personnel, vehicles, measuring stations, and the like.

Variables are attributes of the system which may take on different values as the state of the system changes. Of most importance will be the time to perform specific tasks, 'windshield time' of personnel, and work backlog levels.

Parameters are system attributes which do not change because of anything which has happened within the system. These include the distribution of performance times, the number of well connects, and the geographical area.

Relationships tie the components, variables, and parameters together and ultimately determine how the system will operate. Relationships are physical (e.g., distance), functional (e.g., machine reliability), and/or time dependent.

MODEL COMPUTERIZATION

After checking for reasonableness and completeness, making sure all important components and relationships were accounted for, the model was put on the computer. Computerization allows multiple alternatives to be investigated with a minimum of lead time, summarization of desired information, and the use of existing data bases reducing the time required to 'code in' the system under study.

Before using the computer model for the analysis of an existing system, the model should be validated using actual historical data and comparing the results to actual figures.

All random events are handled using the Monte Carlo simulation technique and the proper statistical distribution from historical data.* The program was written using FORTRAN and the GPSS V simulation language, and set up to run on an IBM 370 series computer system.

DATA REQUIREMENTS

In order to describe the gathering system and satisfy the data requirements of the model, the following information is needed.

(1) All operation and maintenance tasks to be performed (See Figure 1)
  - (A) Scheduling instructions
  - (B) Task priority to be used in scheduling

(2) Field descriptions for each task (See Figure 2)
  - (A) Field number and location
  - (B) Number of facilities in the field requiring the service
  - (C) Field priority to be used in scheduling
  - (D) Standard time for the task by field
  - (E) Average distance between facilities
  - (F) Percent of paved roads

(3) Crew, equipment, and vehicle requirements for each task

(4) Crew profile (See Figure 3)
  - (A) Number of each skill type
  - (B) Cross-training schedule for each crew member
  - (C) Proficiency of each crew member at main skill and cross-trained skills
  - (D) Vacation time of each crew member

*George S. Fishman, Concepts and Methods in Discrete Event Simulation (New York, 1973) p. 17.

(5) Time period to be included in the study
   (A) One month to three years
   (B) Indicate company holidays

(6) Climate description by month for the area (From the United States Climate Atlas)

(7) Performance factor adjustments based on the weather

(8) Special instructions

The bulk of this information should be available from the firm's operation and maintenance manuals and from the area operating offices.

FUNCTIONS OF THE MODEL

The computer model compiles the input data and performs the following general steps in simulating the actual operation of the gathering system. (See Figure 4)

(1) Produces a calendar of available work days with each days weather and associated work performance factors. (See Figure 5)

(2) Produces a monthly task schedule using the provided instructions. (See Figure 6)

(3) Produces a daily schedule for each field from the monthly schedule and the work backlog.

(4) Schedules and sends crews to perform tasks from the daily schedule based on task priority and crew and equipment availability.

(5) Accumulates and summarizes all relevant statistics associated with the gathering system operation.

(6) Presents statistics in a form desired by the user.

The gathered statistics may be broken out by specific field, type of task, or crew skill group, as well as total system figures. This information is also available in graphical and tabular form as specified by the user. (See Figure 7)

SUMMARY AND COMMENTS

The Pipeline Gathering System Operations Model was developed as a tool to help analysts identify and quantify critical factors in pipeline operations. At a time when gathering systems are becoming more complex and labor intensive, the model seeks to summarize system information and expose areas of weakness.

The model allows the evaluation of operating costs and requirements of a proposed system at the time the facility requirements are estimated, and not after the gathering system has been constructed and brought on-line.

The model also enables the evaluation of the effects on operations and savings due to new technologies, such as facility automation and facilities with reduced maintenance requirements.

And finally, crew scheduling techniques, an area of continuing research, may be tested without the interruption of existing system operations.

FIGURE 1.

* SCHEDULING INSTRUCTIONS *

DAILY-BSTR INSP	TASK NO.	6	PRIORITY	6	5	41	42	43	44	45
RADIOGRAPHY-INS	TASK NO.	4	PRIORITY	8	5	41	[illegible]	43	44	45
REGULATOR-INSP	TASK NO.	22	PRIORITY	14	1	43	0	0	0	0
CHART CHANGING	TASK NO.	3	PRIORITY	17	2	1	42	0	0	0
8-DAY CHARTS	TASK NO.	2	PRIORITY	20	4	1	9	17	24	0

FIGURE 2.

FIELD DESCRIPTIONS BY TASK

DAILY-BSTR INSP TASK NO. 1

FIELD NO.	NO. AT FLD	FIELD PR	S.I. (MIN)	STD DEV %	DIST-B-LOC	% PAVED RD
1	4	2	10	25	15	50
2	3	1	10	25	20	20
3	7	3	10	25	50	80
4	2	4	10	25	40	100
5	0	5	0	0	0	0

FIGURE 3.

CREW PROFILE

JOB CLASSIFICATION--CONTR TECH

CROSS-TRAINED SCHEDULE

CONTR TECH	CORSN TECH	EQUIP ANAL	HVY EQ OPR	LHT EQ OPR	MAIN FLDMN	MEAS TECH	OPER FLDMN	REPAIRMAN	WELDER	WELD HELPR
1	3	3	0	0	2	0	0	0	0	0

JOB CLASSIFICATION--CORSN TECH

CROSS-TRAINED SCHEDULE

CONTR TECH	CORSN TECH	EQUIP ANAL	HVY EQ OPR	LHT EQ OPR	MAIN FLDMN	MEAS TECH	OPER FLDMN	REPAIRMAN	WELDER	WELD HELPR
0	1	3	0	0	0	0	0	2	0	0

SCALE

1 - VERY SKILLED

2 - AVG SKILL

3 - SOME TRAINING

0 - NO EXPERIENCE

FIGURE 4.

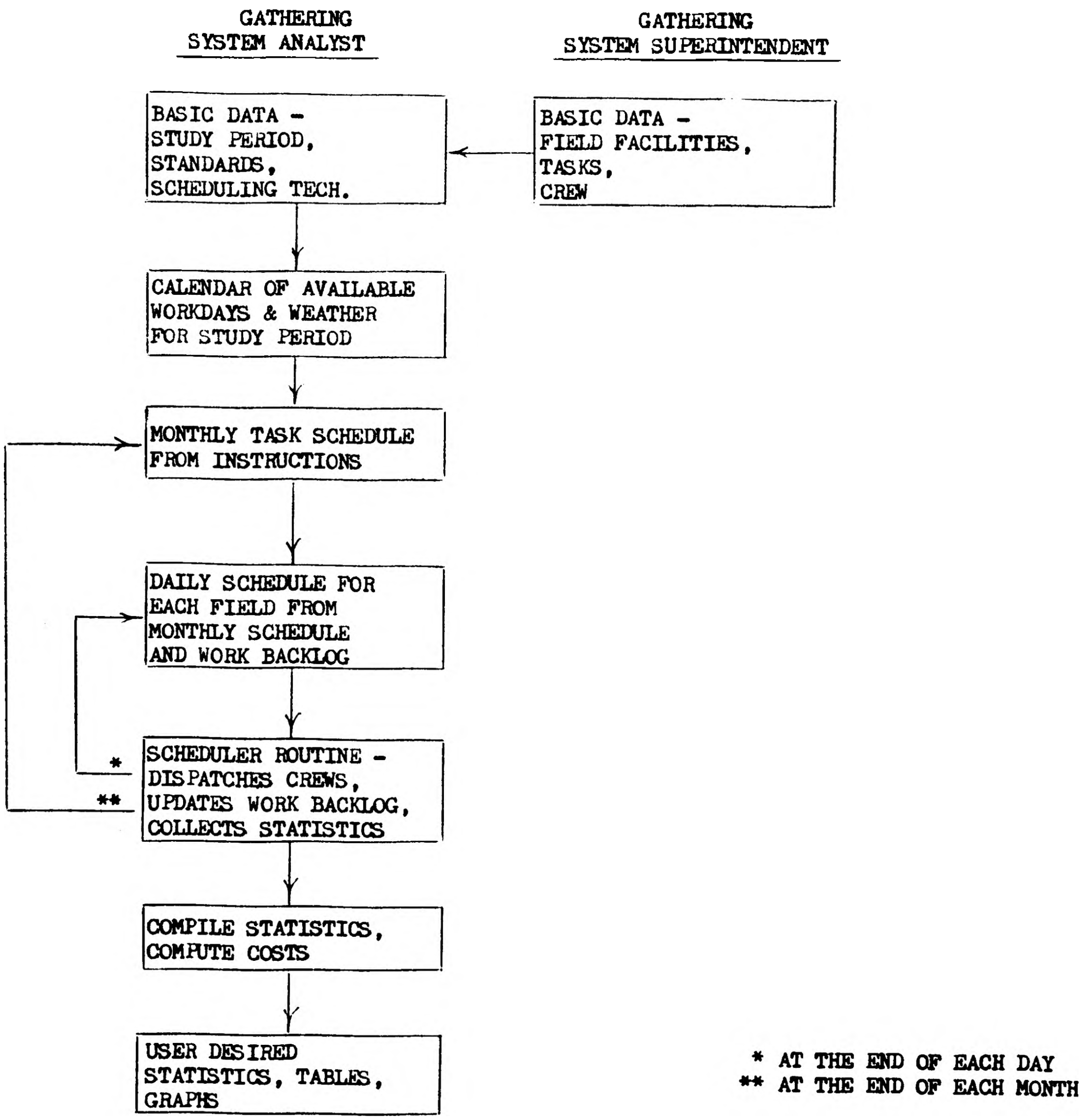


FIGURE 5.

WORKING DAY CALENDAR SCHEDULE

DEC 1981

M	T	W	T	F	S	S
0	12	12	12	12	12	12
0	1	2	3	4	5	6
0	1	1	1	1	2	2
0	2	3	4	5	6	7
0	0	35	10	0	0	50
0	0	70	20	0	0	80
0	0	25	10	0	0	50
0	0	90	50	0	0	80
0	0	4	1	0	0	2

M	T	W	T	F	S	S
12	12	12	12	12	12	12
7	8	9	10	11	12	13
1	1	1	1	1	2	2
1	2	3	4	5	6	7
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	0

M	T	W	T	F	S	S
12	12	12	12	12	12	12
14	15	16	17	18	19	20
1	1	1	1	1	2	2
1	2	3	4	5	6	7
0	0	10	0	10	0	0
0	0	20	0	20	0	0
0	0	10	0	10	0	0
0	0	50	0	50	0	0
0	0	1	0	1	0	0

M	T	W	T	F	S	S
12	12	12	12	12	12	12
21	22	23	24	25	26	27
1	1	1	1	1	2	2
1	2	3	4	5	6	7
0	0	10	10	0	10	0
0	0	20	20	0	20	0
0	0	10	10	0	10	0
0	0	50	50	0	50	0
0	0	1	1	0	1	0

M	T	W	T	F	S	S
12	12	12	12	0	0	0
28	29	30	31	0	0	0
1	1	1	1	0	0	0
1	2	3	4	0	0	0
10	0	0	50	0	0	0
20	0	0	80	0	0	0
10	0	0	50	0	0	0
50	0	0	80	0	0	0
1	0	0	2	0	0	0

DESCRIPTION OF ROWS

1. MONTH
2. DAY OF MONTH
3. TYPE OF DAY (WORKING OR NON-WORKING)
4. DAY OF WEEK

5-8. PERFORMANCE FACTORS DUE TO WEATHER

9. DAY'S WEATHER

FIGURE 6.

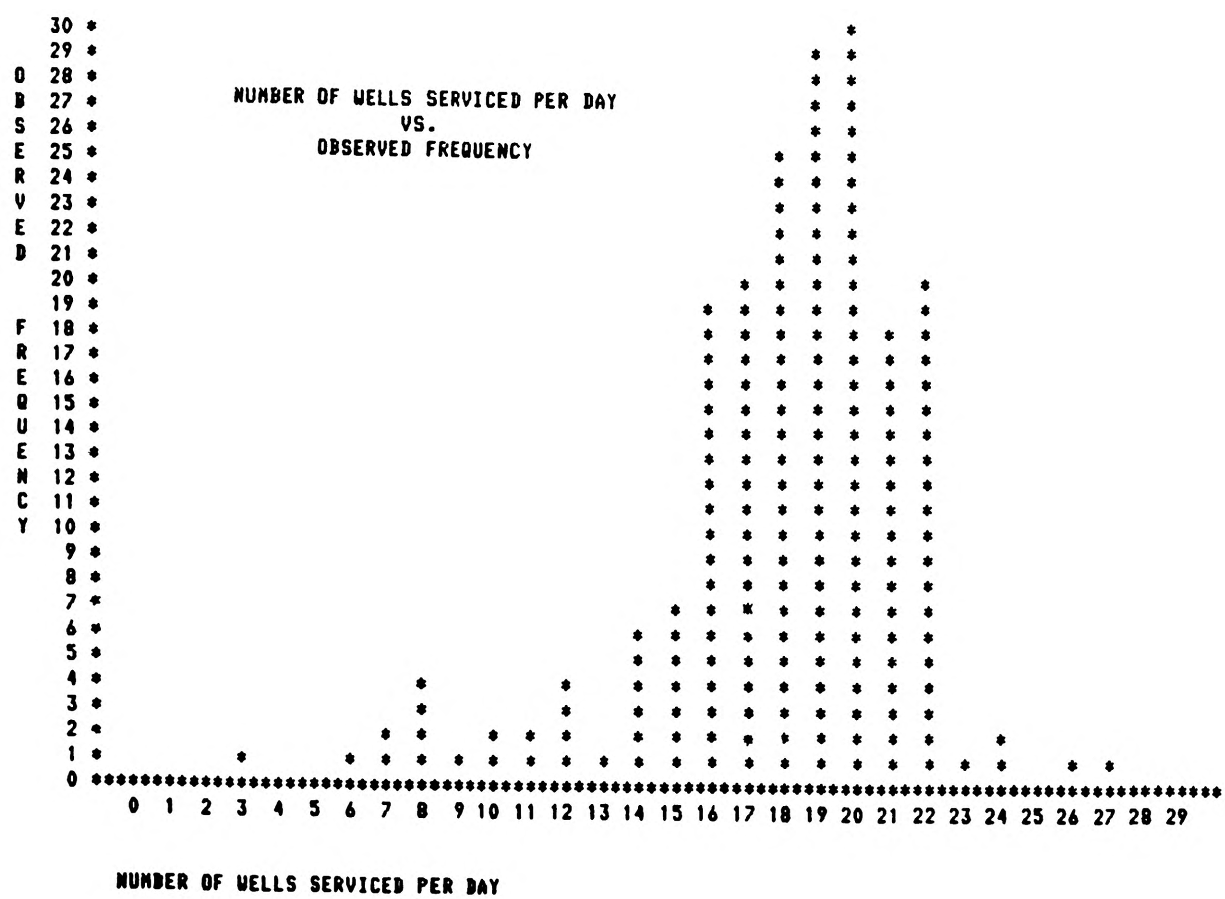
MONTHLY SCHEDULE FROM INSTRUCTIONS

SCHEDULE FOR JAN 1979

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TASK NO.	6	6	6	6	6	0	0	6	6	6	6	6	0	0	6
PRIORITY	6	6	6	6	6	0	0	6	6	6	6	6	0	0	6
TASK NO.	4	4	4	4	4	0	0	4	4	4	4	4	0	0	4
PRIORITY	8	8	8	8	8	0	0	8	8	8	8	8	0	0	8
TASK NO.	0	0	22	0	0	0	0	0	0	22	0	0	0	0	0
PRIORITY	0	0	14	0	0	0	0	0	0	14	0	0	0	0	0
TASK NO.	3	3	0	0	0	0	0	0	3	0	0	0	0	0	0
PRIORITY	17	17	0	0	0	0	0	0	17	0	0	0	0	0	0
TASK NO.	2	0	0	0	0	0	0	0	2	0	0	0	0	0	0
PRIORITY	20	0	0	0	0	0	0	0	20	0	0	0	0	0	0
TASK NO.	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIORITY	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0
TASK NO.	0	8	0	0	0	0	0	8	8	0	0	0	0	0	0
PRIORITY	0	27	0	0	0	0	0	27	27	0	0	0	0	0	0
TASK NO.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIORITY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TYPE DAY	1	1	1	1	1	2	2	1	1	1	1	1	2	2	1
WEEKDAY	1	2	3	4	5	6	7	1	2	3	4	5	6	7	1

	16	17	18	19	20	21	22	23	24	25	26	27	28	29
TASK NO.	6	6	6	6	0	0	6	6	6	6	6	0	0	6
PRIORITY	6	6	6	6	0	0	6	6	6	6	6	0	0	6
TASK NO.	4	4	4	4	0	0	4	4	4	4	4	0	0	4
PRIORITY	8	8	8	8	0	0	8	8	8	8	8	0	0	8
TASK NO.	0	22	0	0	0	0	0	0	22	0	0	0	0	0
PRIORITY	0	14	0	0	0	0	0	0	14	0	0	0	0	0
TASK NO.	[illegible]	0	0	0	0	0	0	3	0	0	0	0	0	0
PRIORITY	17	0	0	0	0	0	0	17	0	0	0	0	0	0
TASK NO.	0	2	0	0	0	0	0	0	2	0	0	0	0	0
PRIORITY	0	20	0	0	0	0	0	0	20	0	0	0	0	0
TASK NO.	23	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIORITY	26	0	0	0	0	0	0	0	0	0	0	0	0	0
TASK NO.	8	0	0	0	0	0	0	8	0	0	0	0	0	0
PRIORITY	27	0	0	0	0	0	0	27	0	0	0	0	0	0
TASK NO.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRIORITY	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TYPE DAY	1	1	1	1	2	2	1	1	1	1	2	2	2	1
WEEKDAY	2	3	4	5	6	7	1	2	3	4	5	6	7	1

FIGURE 7.



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BIOGRAPHY

Mark E. Ryan is employed by Panhandle Eastern Pipe Line Company. Currently on an educational leave-of-absence from Panhandle, he instructs an introductory computer programming course at the University of Arkansas where he plans to complete requirements for an M.S. degree in Industrial Engineering in December, 1980. Mark received a B.S.C.E. from the University of Missouri - Rolla in 1977.