A PIPELINE CONSTRUCTION SYSTEM

submitted
in partial fulfillment
of the requirements
for the degree of
Master of Science

by

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November 21, 1983
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INTRODUCTION

The construction of a pipeline for the transportation of natural gas and other fluid products is a wide-ranging task. The pipeline company's management needs to keep track of the different phases of the project, monitoring the progress of construction and the rate of expenditures in order to keep effective control over personnel and financial resources.

When two or more companies form a joint venture to construct a pipeline, the management of construction data takes on added significance for the justification of progress and expenditure. In addition to keeping track of the day-to-day progress of construction on a pipeline, the pipeline company needs to maintain historical records on a project. The potential of future lawsuits on the part of landowners, contractors, or partners requires the maintenance of accurate records, which might be used as evidence in court.

Such a system requires that footage data be kept for specific categories of a pipeline construction project: right-of-way clearing; stringing of pipe along the right-of-way; digging of the ditch; welding the joints of pipe together; lowering the pipe into the ditch; backfilling the ditch; and cleaning up the right-of-way. In addition, comments justifying or explaining each day's progress are also required.
A project consists of one or more pipe sizes, each of which is considered a separate sub-entity within the project. Each pipe size has its own footage estimate and cost estimate, which should be maintained separately for valid comparisons.

This system was requested by a senior-level vice-president of Coronado Transmission Company. The student held discussions with this person to determine management's requirements for data to be kept and for reporting of that data. Management's expectations were also discussed, as well as the current manual method of record-keeping.

The student also discussed the system with the user who is directly responsible for the maintenance of the data and the generation of daily reports on pipeline construction, the manager of gas measurement. Additional features, such as a complete historical report and increased capacity for storage of comments, were defined through discussions with this person.

Finally, the student met with the user who is responsible for actual data input and printing of the reports, to discuss data input features, terminal constraints, and other considerations of interest to this user.

The student took a top-down, structured approach to the design of the system. Due to the relatively limited data flow, data structure-oriented design rather than data-flow oriented design was implemented (Pressman, Software Engineering, pp. 205-215; Weinberg, Structured Analysis, 83-98). Data organization, optimization of storage and reporting of the
data constituted the primary concerns of the designer. The file design is discussed later.

Ease of use and integrity of input data formed primary considerations in the program design stage. The structured approach becomes evident here especially in the design of the data entry program. Also, editing of input data to some degree ensured that many future errors might be avoided.

The project also involves the specification and installation of communications and remote terminal equipment for operation of the system. These steps were required because the primary users of the system are located in an office six miles from the computer site.

Another aspect of the project consists of incorporating financial data into the construction reports. The financial data is stored in an accounting data base, installed and maintained by a software vendor/computer service bureau. Authorization to access the data base required three separate meetings with the vendor's sales and systems representatives.

The student wrote the programs in COBOL, using a structured, modular approach (Davis and Fisher, COBOL, pp. 133-160; Ledin, et al., The COBOL Programmer's Book of Rules, pp. 64, 100, 134-137; and Heninger and Shore, "Designing Modular Programs", in Computer Programming Management, pp. 49-67).
CHAPTER 1

The idea for this project emanated from a request by the vice-president for operations of Coronado Transmission Company, a natural gas pipeline company. This company's principal business is building pipelines and purchasing, transporting, and selling natural gas.

Because of the importance of pipeline construction to the company, management requested a system for keeping track of pipeline construction progress. Management required a daily report of construction progress for all active construction projects. As initially explained, a project might consist of more than one pipe size (e.g., 4-, 6-, or 10-inch diameter pipe). Data for each of these pipe sizes needed to be kept separate. Data for each pipe size included a cost-of-construction estimate and a total footage estimate, as well as daily construction figures, which are broken down into the seven categories mentioned earlier.

FILE DESIGN

These factors indicate that file design should include a project master file to include one-of-a-kind data associated with each project. Data in this master file should include
a project number, the project status (active or complete);
company indicator (Coronado has several sub-companies which
also might construct pipelines); project location; project
beginning date; and the pipe sizes associated with the project.

Because each pipe size also has data unique to it, a pipe
file is also indicated. The student decided to include cumu-
labative inception-to-date footages in these pipe records, in
order to provide fast access to current construction progress.
The pipe record allows for: a key of concatenated project number
and pipe size; estimated cost of construction; estimated total
footage; the date of the most recent data entered into the
system; and cumulative footages for each of the seven construc-
tion categories (right-of-way, stringing, ditching, welding, low-
ering-in, backfilling, and cleanup).

The design also included a detail file, with one record
for each day's construction figures for each pipe size. This
file would provide historical detail over the life of a project,
indicating the daily progress of the construction in each
category. Fields included in this file's records are: a key of
concatenated project number, pipe size, and date (yyymmdd); and
a field for footages in each of the seven construction
categories.

A secondary discussion with the vice-president of operations
and the manager of gas measurement revealed the fact that
comments are needed to explain or justify construction progress
for each day. Initially, these users described the comments as
brief, so the student considered the possibility of including a
comment field of 20-30 characters in the detail file layout. Further discussion, however, revealed that some construction foremen are capable of lengthy comments. Therefore, an additional file for comments was also designed.

To conserve disk space, the system allows for a variable number of comments for each day's construction on each pipe size. A comment code field is included in the detail file to indicate whether one of several standard comments applies, or whether the comment file contains comments for that day's construction. The comment record consists of: a key of concatenated project number, pipe size, date, and a sequence number that is automatically assigned to the comment; and a 110 character comment. Initially, the system allowed a maximum of five comment records for each date, but the wordiness of one foreman dictated an increase to a maximum of eight comment records.

Hewlett Packard's Key Sequenced Access Method, an indexed sequential access method, was chosen as the access method for implementation of the files in the pipeline construction system.
Programming

Programming for the system was divided into four separate programs: an interactive data entry program; an interactive parameter-selection program for the report program; a batch report program; and a general-purpose file maintenance program. The project initially called for a separate accounting data-base access program, but further research showed that including this function as a separate routine in the report program would work better.

Programming for the data entry program proceeded on the assumption that data will be entered daily, for as many projects as are active at any particular time. Therefore, the program calls for the entry date to be entered first by the user. This date will then be applied to all subsequent data entered for that date, until a new date is entered. The next routine in the top-down scheme calls for the entry of the project number, then for individual pipe sizes within a particular project. Data is entered on the basis of pipe sizes. The user enters all data in response to prompts from the program.

The capability to modify records in all files is of great importance. Footages as reported from the field may be found to be in error, data entry errors may occur, or adjustments to relatively static data may be necessary. For example, the cost estimate for a pipeline may increase as difficulties in construction arise.
For these reasons, the user is capable of modifying any field in any file with the exception of key fields. Another cumulative total fields of the pipe file constitute another exception. These fields are protected from user modification because changes to daily data result in automatic modifications to the cumulative fields.

Additions and modifications to the master project file and the pipe file are handled in a similar manner. The primary difference is that the program verifies the existence of the project before it allows the user to modify either file. The most common changes to project master records involve changing the status field, which is coded either 0 (active), 1 (inactive or complete), or 9 (to be deleted). Another normal change might be the addition of a new pipe size.

In the pipe file, the user would be most likely to change the cost estimate or the total footage estimate.

In order for a user to change a daily footage amount in a detail file record, he must enter a code to indicate what construction category he is going to change. For example, the user would enter "ROW" in order to change the right-of-way footage.

Some changes to the files automatically set other changes. For example, the addition of a new pipe size automatically results in the addition of a new pipe record in the pipe file. Similarly, a change in the comment code of the detail file prompts the user for changes to the comment file for that date.
The data entry program also allows on-line inquiry into any of these files.

The second program is an interactive program that allows entry of parameters that are used by the report program. This program allows the user to specify a report based on: the most recent data entered in the detail file; a specific date prior to the most recent date; or a historical detail report listing all the construction activity on a project. In any of the three cases, the user has the option to access the data from the accounting data base. The user can specify up to twenty sets of parameters for the subsequent report program run.

The report program was originally intended to be interactive, but the possibility of extensive disk accesses for both construction files and the accounting data base indicated that a batch approach should be used in order to minimize system degradation for other on-line users.

The report program generates the most-recent-data report and the historical-data report for a specific project or all active projects, depending on the user's parameter selection. The specific-date report generates a report for only a specified project. The most-recent-data report uses the cumulative totals of the pipe file, while the other two reports accumulate the these figures from the beginning date of the project.

Finally, a general file maintenance program was written. This program is used to modify the four files without going through the regular data entry program. This program will not
be released to the users, but will be used by the data-processing
department to make emergency changes to the files. This program
allows modifications, additions, and deletions to any of the file
Great care should be exercised in using this program, because
few edit checks are made on the data.

The general file maintenance program was written using
Hewlett Packard's UPLUS/3000, a screen management software system
that provides interface between the terminal and the
user's transaction-processing program.

TESTING

Testing of the system indicated that the fields for
cumulative footages in the pipe file needed to be enlarged
from five digits to six digits. Also during the testing phase,
management made minor modifications to report formats.

HARDWARE ACQUISITION

Because the primary users of the system are located in an
office six miles from the computer site, use of this system
required additional equipment. A Hewlett Packard 2640B terminal
and a Hewlett Packard 2631B serial printer were selected for the
data terminal equipment. Installation of these two pieces of
equipment, as well as the probability of expansion in the near
future, indicated that multiplexers and 2400 bit-per-second
modems should be installed as communications equipment.
The Halcyon 4001 Stat Mux was chosen to multiplex the signals,
and the Paradyne LSI 24 modem was chosen for transmission over
the telephone line. A four-wire data circuit was installed
between the computer site and the remote office. The multi-
plexors use a proprietary, synchronous protocol in full-duplex
mode. As the multiplexers have four ports, two additional
terminal devices can be added at the remote site. A four-wire
voice-grade data circuit was installed between the computer site
and the remote office. Selection of this equipment makes the
communications function transparent to the remote user.
SUMMARY AND CONCLUSIONS

The pipeline construction system described in this paper was designed to meet the specific needs of Coronado Transmission Company. As it exists now, the system meets those needs. The first construction project to be implemented on the system is a $10,000,000 project which Coronado is conducting in partnership with a larger corporation. As such, the demands for flexibility and data accuracy are probably as stringent now as will ever be required for this system.

The section of code for accessing the accounting data base was added after the system had been in use for several weeks. The addition went smoothly, reinforcing the value of modular program construction.

Conversion of the data entry function from direct COBOL input to the VPLUS/3000 facility would probably improve the system's user-friendliness and would be the next logical modification of the system. Also, conversion of the KSAM files to Hewlett Packard's IMAGE data base management system would probably increase file flexibility.

These facilities were not utilized initially because of the need for rapid installation of the system. Once the system was installed, the student has had the opportunity, and to learn about both of these facilities. In the initial phases of the project, however, learning about IMAGE and VPLUS would probably have substantially delayed implementation.
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