A SAS BASED MATERIALS TRACKING SYSTEM

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ABSTRACT

The role of the Transmission engineering Section of the San Diego Gas & Electric Company (SDG&E) is to enable the provision of overhead and underground power systems. Such systems satisfy the energy demands of a growing consumer base. An assigned project engineer is responsible for the installation of a given transmission line. The project engineer, therefore, is concerned with the engineering and design of the line, as well as overseeing the procurement, construction, and inspection phases which precede placing the line in service. The measures of project success are accomplishing the performance specifications of the transmission line on or before the scheduled deadline and within the budgeted cost. A crucial factor associated with these three determinants of project success is material. Specifically, deviations from availability of the right material in the necessary quantity at the proper time invariably contribute to project delay, cost overruns, and possibly deficient energy transmission. This paper describes the SAS based materials tracking system developed at SDG&E to assist the project engineer in favorable accomplishment of transmission line projects.

SAS was selected as the computer language appropriate for the SDG&E material tracking system due to several reasons. SAS enabled the modeling of this prototype system in a time and cost-effective manner. Moreover, the language’s ability for information storage and retrieval, report writing, and file management was more than adequate for this application. Our materials tracking system has been successfully applied since the Fall of 1980, and has served to again demonstrate the power of the SAS language to the SDG&E computer user community.

BACKGROUND

The San Diego Gas & Electric Company is an investor-owned public utility that generates, purchases and distributes electricity to nearly 300,000 customers in San Diego County and to portions of Orange and Imperial Counties in California. SDG&E also purchases and distributes natural gas to more than 500,000 customers in San Diego county. The Company employs approximately 5,000 people and has an annual operating revenue of over $1.2 billion.

The stages of production and delivery of electrical power to consumers are illustrated in Exhibit 1. Transmission lines carry electricity generated by a power plant from one substation to the next. These transmission lines are rated at 69KV (kilo-volts), 138KV, 230KV, or 500KV. The substations perform the function of transforming the electric power into higher or lower voltages. Reduced voltages of 12KV, and less, are carried by distribution lines that connect one substation to another, or link the consumer to a substation. Residential homes, for instance, ordinarily operate on a 120/240 volt distribution line.

The Transmission Engineering Section of SDG&E is responsible for the engineering and design of various transmission line projects. Such projects entail the provision of underground and overhead power systems rated at 69KV and above. A project engineer is assigned to a particular transmission line project to coordinate the specifications phase of the line. The project engineer also monitors the procurement, construction and inspection phases of the transmission line installation. Placement of the line into service concludes the project engineer’s obligation.

A few years ago, the construction of a transmission line was almost halted due to the lack of a “sleeve” which joins together sections of conductor. Although the project engineer had ordered this inexpensive yet necessary connector, the Company’s sluggish and largely manual materials information system was unable to forecast this potential construction problem. Fortunately, the required sleeve was obtained from an alternate source and the construction of the line was allowed to proceed in a timely manner. The occurrence of this near calamity prompted the Transmission Engineering Section to request the SDG&E Data Processing staff to enhance the Company’s materials system. The Data Processing Section was unable to immediately address this need due to their backlog.
of other projects. Given the urgency of the situation, the alternative of developing a prototype system became viable. The intent of the prototype concept was to provide an automated materials tracking system that would serve the fundamental needs of the Transmission Engineering Section until the resources of the Data Processing Section became available to provide a more comprehensive materials system. As noted by Martin [1], this prototyping approach is becoming quite prevalent in the data processing industry.

The overall development of the automated materials tracking system occurred in three stages. The first stage involved definition of the data requirements for the system. These data requirements were identified from the existing manual materials system. The second stage focused on the design of the data entry forms. Examples of these forms are provided in the next section of the paper. The third stage was devoted to development of the software and procedures for updating and maintaining the database. Included within this third stage was selection of the computer language to be used for the materials tracking system. SAS was chosen as the development tool for several reasons:

- High level language capability
- Ease of program and database development and maintenance
- Comprehensive file handling and report writing facilities
- Availability of training materials
- History of successful use of SAS in prototype applications

The SAS based materials tracking system was designed at the outset to be easy to use and simplistic, while providing information on a timely basis for system users. The nature of transmission line projects necessitates requests for unusual materials and/or requests for extraordinary quantities of materials. Since its inception, the SAS based materials tracking system has been denoted the "RUH" system, in recognition of such Requests for Unusual Materials.

THE RUH SYSTEM

The sequence of events which transpire during a transmission line project are highlighted below. Use of the SAS based RUH system for tracking the project's materials is described within this scenario. Further specific details (e.g., listings of the SAS programs, job control and computer run procedures) related to the RUH system are documented elsewhere (see Reference 2).

Exhibit 2 portrays the life cycle of a transmission line project. The impetus for such a project is generated by three primary factors: economics, consumer demand, and maintenance. Economic factors dictate how the lowest cost for a kwh (kilowatt hour) can be achieved. Often, costs to construct a new transmission line will more than offset the cost of a new power plant. Increased consumer demand from a growing community is typically accommodated by enlarging the conductor size of an existing circuit, whereas the power requirements for a new residential community or commercial district require the construction of a transmission line. The maintenance effort may be associated with storm damage or deteriorated structures which necessitate immediate repair. Other maintenance involves relocating a line due to highway construction or to allow room for a new building.

Based on the service demand, the Transmission Planning Section submits a planning request to Transmission Engineering. Included within the planning request are specifications for voltage, conductor size, structure type (e.g., wood pole, steel pole, or steel tower), related substation construction and the projected route for the line. Transmission Engineering then contacts the Land Department for support of right-of-way and survey data, as well as for the preparation of plan and profile drawings. These drawings are used by Transmission Engineering to establish cost-effective positions of structures relative to the roads, canyons, railroad crossings, and other physical/topographical characteristics of the route. Additionally, engineering and design work is performed by Transmission Engineering to provide specification of steel towers, steel poles, conductor, conductor hardware, and overhead ground wire assemblies as required for the line. Construction drawings, refined schedules and a preliminary material list are included in the job package. The preliminary material list is summarized on the RUH forms (see Exhibit 3) by the project team assigned to the transmission job. Listed in Exhibit 4 is the nomenclature associated with this RUH form, as well as with the reports generated by the system.

The completed RUH forms are forwarded to Inventory Control and MOPAC (Managed Order Process and Control) is informed of this RUH issue transmital. MOPAC serves as a communications
monitoring system at SDG&E. Inventory Control contacts MOPAC when the RUM forms are received.

Card images of the materials data from the RUM forms are then stored as an OS file for input to a SAS program. This program adds the new materials data to the SAS data set which serves as the database for the RUM system. A second SAS program uses formatted output and MACRO definitions to produce the RUM system's customized reports. These reports display the source data sorted according to the information needs of the report recipients. The report distribution and related exhibit numbers are summarized by the table in Exhibit 5.

Inventory Control has the responsibility of maintaining an adequate materials supply. The RUM report, sorted by stock number, forecasts Transmission Engineering's composite material requirement for each stock item over time. Inventory Control issues Purchase Orders to suppliers to meet these projected needs. The Date Required Report enables Inventory Control to ascertain the lead time requirements for procurement. Such assessment allows for a timely but not excessive lead time for ordering the required material. Inventory is thereby kept to a minimum, thus reducing unnecessary warehousing costs.

The RUM report sorted by work order number is received by the Supervisor of Transmission Engineering and is useful in identifying the section's projects entering the construction phase. The report sorted by date issued permits determination of whether sufficient lead time has been allowed for the procurement of project materials. Such lead times average approximately six months. The Supervisor of Transmission Engineering also receives the job package from the project team. A construction award is made either to the appropriate SDG&E operating district or an outside contractor based on the project magnitude and estimated cost. Once the Transmission Engineering Supervisor releases the job issue, manpower assessments are determined by the responsible construction force.

Project Storage serves to centralize the materials required for a given project by stockpiling shipments received from suppliers. Segregation of material by projects can be a complicated task. The RUM work order report aids in reducing this complexity. This report identifies the proper distribution material as well as how the material is to be charged for accounting purposes. Once all the material for a given project has been stockpiled, Project Storage forwards a Material Status Report (shown in Exhibit 11) to the Project Engineer.

A project engineer may be involved with many simultaneous projects. Consequently, the task of tracking materials on different transmission lines can be unwieldy. The RUM report sorted by designer readily allows the project engineer to answer material queries for any given job.

The Material Status Report, once received by the project engineer from Project Storage, signals that the materials data for the given workorder is to be deleted from the SAS database. An OS file of the card images for data deletion is then created. This input is supplied to a third SAS program which employs MERGE and DELETE instructions to update the SAS data set. Additionally, the project engineer submits a copy of the original RUM forms marked "complete" to Inventory Control, and instructs MOPAC of this RUM release transmittal. Inventory Control, upon receipt of this notification, confirms the release with MOPAC.

The construction of a transmission line circuit begins when the construction force receives the job issue from the Transmission Engineering Supervisor. The materials from Project Storage for the job are consumed on an as needed basis. This construction phase may last from a few weeks to several months. Upon completion, the circuit is tested. The line is then placed into service.

IMPACT OF THE RUM SYSTEM

Users of the SAS based RUM system have been polled to ascertain impressions of the system's impact upon their area of responsibility. Listed below are three representative declarations concerning the utility of this system:

"As a Senior Designer responsible for multi-million dollar electric transmission line projects, including design, schedules and budget control, I have found the RUM Program most beneficial.

One of the major considerations in line construction is availability of the proper material when needed. Lack of even a minor part can bring work to
a stop. This automatically affects final cost as well as the construction schedule. This is especially important when the work is being done by a contractor.

Prior to this system, memos were sent to Material Control to advance notice prior to issuance of work order of material requirements. This practice was not found to be entirely satisfactory with many material delays. With the new system we now have, in addition to notification, required acknowledgment of receipt of request and a status report of shortages prior to wanted date.

With the system now in use fewer delays are experienced and the worry that material will not be available has been lessened. Since human elements are involved, breakdowns do occur. However, if both the requestor and requestee notify the other of changes and/or problems, difficulties would be eliminated."

F. J. Lantry, Senior Designer, Transmission Engineering Section, Electrical Engineering Department

"The large volume of material required for jobs of this nature dictates the necessity for special consideration. Material Management Department uses the output from the Materials Tracking System as a means of determining material requirements. As the material requirements are updated by the Tracking System, Material Management makes adjustments accordingly. This system has proven to be a good interim procedure for handling this type of material requirement while the company completes the improvements to the Material Management System."

J. N. Jolley, Inventory Control Supervisor, Inventory Control Section, Material Management Department

"The role of the Material Management Section of SDG&E is designed to support (i.e., material support) the Transmission Engineering Section of SDG&E.

An assigned project from the Transmission Engineering Section is given to the Section Stockkeeper from a Transmission Material list. This list contains general notes and provisions as to how material is to be distributed and stored. Usually all construction work is contracted, therefore, the material list will include all exempt material for transmission and distribution construction projects.

The Section Stockkeeper works directly from a material list or RUM report which informs him item for item, the stock number, part number, description, location of where material is located and the quantity required for the particular project.

Material is stocked at Project Storage or Miramar Yard and quantities are charged by various locations throughout the districts. The Section Stockkeeper distributes paperwork (warehouse charges, credits, etc.) for each individual project. Material is then staged in proper locations for pickups from contractors. Job completion memos are typed and notification to Designers and Project Engineers are distributed.

As a Section Stockkeeper for Material Control, I have found the RUM Report to be the most rapidly developing area at Material Control. As the material requirements are updated by the Tracking System, we at Project Storage are better informed as to what material has been ordered, and also as to what project the material is for. It also provides for better tracking of material and quantities processed with the correlation between project and engineer. This in itself is very helpful when staging projects."

Chris E. Rohrbach, Section Stockkeeper, Project Storage Section, Material Control Department

A fundamental, yet subtle, benefit of the RUM system deserves mention in addition to those cited above. Specifically, the SAS based materials tracking system has promoted more meaningful communication between diverse segments of SDG&E which contribute to the successful completion of a transmission line project. Reports from the RUM system have encouraged use of a common vocabulary, which in turn has lessened the possibility of misunderstandings between project participants.

The RUM system has, as originally intended, enabled users to document and track material requests; and allows immediate identification of the status of materials necessary for transmission projects prior to the construction phase. Other groups within the company which have project responsibilities similar to Transmission Engineering are recognizing the RUM system as potentially useful for their materials tracking requirements. The RUM system has acted as a catalyst for members of Substation Design, Gas Engineering, and Electric..."
Distribution Engineering to voice their concerns and support of the company's current endeavors to improve the Material Management System [3]. Moreover, the Southwest Powerlink Project is currently considering adoption of the RUM system for their operations. This project, incidentally, is representative of a key operating strategy of SDG&E to reduce dependency on oil for electric supply. The Southwest Powerlink is a 280-mile, 500-kilovolt transmission line connecting San Diego with cheaper, coal-fired power from other Southwest utilities.

Another possible extension of the RUM system is illustrated in Exhibit 12. Depicted in this diagram is a conceptual system for minicomputer application that would automate much of Transmission Engineering's activities for summarizing and estimating schedules, job materials, labor, overhead, and general costing. Shown in the lower left portion of the diagram is the RUM system. This proposed system is again representative of the company's endeavors to upgrade the level of automation for all possible applications. Moreover, SAS could be used for making this conceptual system operational.

In retrospect, our SAS based materials tracking system has been successfully applied since the Fall of 1980. Use of the SAS language on this system represents a pioneering effort to diverge from the company's mainstream applications of the language at that time—statistical analysis studies. The ease by which SAS allowed the RUM system to be developed served to exemplify the productivity potential of the language. Consequently, a training program for SAS was developed at SDG&E to further encourage productivity of employees in the myriad of computer applications which SAS so readily allows [4].

**ENHANCEMENTS**

The acquisition of SAS/FSP (Full Screen Product) in 1981 and RAQL (Relational Algebraic Query Language for SAS developed by McGill University) in 1982, has added flexibility to the RUM system. With SAS/FSP users can now edit and query the RUM database in full screen mode. RAQL was initially used in the delete step, replacing a SAS MERGE with a MINUS operation. The RUM database is currently being reviewed to determine if it would be feasible to restructure it in a relational format, thus allowing greater query flexibility with RAQL [5].

**CONCLUSIONS**

The SDG&E SAS based materials tracking system has proven itself to be a worthwhile vehicle for assisting in the successful completion of transmission line projects. The prototype RUM system eventually will be replaced with the company's forthcoming material management information system. SAS's forte in graphics and statistical analysis could readily play a vital role with this new automated system, as well.

**REFERENCES**


**FURTHER INFORMATION**

The authors welcome inquiries concerning the subject matter of this paper. Interested parties are invited to contact us at the following address.

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### Exhibit 5. RUM Report Sort Fields, Distribution, and Exhibit Reference Number

<table>
<thead>
<tr>
<th>Report No.</th>
<th>Primary Sort Field</th>
<th>Secondary Sort Field</th>
<th>Tertiary Sort Field</th>
<th>Distribute To</th>
<th>Exhibit</th>
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<td>1</td>
<td>Stock Number</td>
<td>Work Order Number</td>
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<td>Inventory Control, Project Storage</td>
<td>6</td>
</tr>
<tr>
<td>2</td>
<td>Date Required</td>
<td>Stock Number</td>
<td>(None)</td>
<td>Inventory Control, Project Storage</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>Designer</td>
<td>Work Order Number</td>
<td>Stock Number</td>
<td>Project Engineer, Project Storage</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>Work Order Number</td>
<td>Stock Number</td>
<td>(None)</td>
<td>Transmission Engineer, Project Storage</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>Date Issued</td>
<td>Work Order Number</td>
<td>Stock Number</td>
<td>Transmission Engineer, Project Storage</td>
<td>10</td>
</tr>
</tbody>
</table>

### Exhibit 6. Example RUM Report Sorted by Stock Number

### Exhibit 7. Example RUM Report Sorted by Date Required

### Exhibit 8. Example RUM Report Sorted by Designer
EXHIBIT 9. EXAMPLE RUM REPORT SORTED BY WORK ORDER NUMBER

EXHIBIT 10. EXAMPLE RUM REPORT SORTED BY DATE ISSUED

EXHIBIT 11. MATERIAL STATUS REPORT FORM
EXHIBIT 12. COMPUTER SUPPORT SYSTEM CONCEPTUAL MODEL