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An Introduction to the New Productivity Information Management System (PIMS)

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This report describes the Productivity Information Management System (PIMS), which is being developed at JPL. The main objective of this computerized system is to enable management scientists to interactively explore data concerning DSN operations, maintenance and repairs, in order to develop and verify models for management planning. Thus, PIMS will provide users with a powerful set of tools for iteratively manipulating data sets in a wide variety of ways. Most current database systems are designed to support a narrow range of predetermined types of queries. Thus, the design of PIMS includes unique, state-of-the-art features. The initial version of PIMS will be a useful but small-scale pilot system. This report (1) discusses the motivation for developing PIMS, (2) describes the various data sets which will be integrated by PIMS, (3) sketches the overall design of PIMS, and (4) describes how PIMS will be used. A survey of relevant databases concerning DSN operations at Goldstone is also included.

I. Introduction

The operation of the Deep Space Network (DSN) costs roughly $59 million a year.[1] The annual cost to JPL of operating the facility at Goldstone alone is roughly $15 million, and involves some 215 contractor manyears (Ref. 1). In this period of financial limitations, even incremental improvements in DSN efficiency yield important savings for JPL; and selections between alternative implementations and policies can have substantial financial implications. These facts underline the utility and necessity of reliable, easily accessible information about DSN operations and expenditures. This report outlines the proposed development of a new computerized system, directed at providing convenient access to some of this information. Although only in the pilot stage, this system will provide very flexible access to an integrated, moderately detailed view of DSN productivity and costs.

Several highly successful computerized information management systems have been implemented at JPL over the past few years to facilitate various aspects of operating the DSN (e.g., the Equipment Database and the Engineering Change Management Databases of Section 377, and the DSN Scheduling Database of Section 371). Each of these systems was developed to accomplish a specific range of tasks concerning a fairly

[1] This includes the operation of the three deep space complexes and the Network Operations Control Center and the logistical and sustaining engineering costs. Long-range planning for advanced equipment and future projects costs an additional $35 million.

narrow aspect of DSN activity. In most instances, these databases were developed independently of the others. For these reasons, it is hard to use these systems to develop an integrated yet detailed picture of DSN operations and expenditures. Furthermore, it is difficult and cumbersome to obtain information of an ad hoc, nonroutine nature from these databases.

To illustrate this point in dramatic but clearly oversimplified terms, we present a brief analogy. Suppose that we were given (1) an alphabetical listing of all JPL employees and their office phone numbers, (2) a listing by section number of all the employees in each section, and (3) a listing, ordered by increasing telephone number, of the charges accrued against each phone during a given month. It is easy to imagine how such different lists could be generated by different groups for different purposes. Suppose now that a listing of the total of charges accrued against the phones in each section were desired. Clearly, it would be cumbersome and time-consuming to provide such a listing. Speaking broadly, management scientists are interested in all kinds of ad hoc, nonroutine aggregate summaries such as this, and the existing DSN databases simply cannot provide them in a rapid, convenient manner.

A second obstacle to developing an integrated view of DSN operations is that important information concerning expenditures is recorded in a variety of different ways. In fact, some of it is not at present recorded electronically. For example, information concerning most of the activity of the Maintenance and Integration Unit at Goldstone is recorded and stored on paper. Furthermore, some information relevant to determining operating costs (e.g., how many manhours are spent in transit between stations) has not, until recently, been recorded at all.

As a first step in resolving this problem, a group working in Division 330 (Telecommunications Science and Engineering) is currently developing the Productivity Information Management System (PIMS). The system will integrate data concerning various aspects of DSN operations. A distinguishing feature of PIMS will be the highly flexible accessing capabilities; users will be given tools for interactively manipulating and analyzing data sets in any way they choose. The initial implementation of PIMS is narrow in scope and will focus entirely on DSN operations at Goldstone. The system is viewed primarily as a pilot rather than as a full-blown, general-purpose tool. However, the system should prove useful to management scientists for the purpose of developing and testing management models, and to both managers and management scientists for the purpose of analyzing current DSN operations and choosing among various future alternatives. The experience gained in implementing and using this pilot version of PIMS can later be used to guide futher expansion of PIMS, and possibly to provide impetus for the development of a considerably more comprehensive information management system for the DSN.

The aim of the current report is to discuss the motivation for developing PIMS, to describe the various data sets which will be integrated by the initial version of PIMS, to briefly sketch the overall design of PIMS, and to indicate how PIMS will be used. In Section II the motivation behind PIMS is discussed in more detail, and the long-range direction of PIMS is considered. Section III presents an overview of the general capabilities of the initial version of PIMS, and Section IV describes the overall design of this initial version. In Section V we describe two examples of how PIMS will be used to integrate data and derive certain types of information. And in Section VI we conclude by indicating the current status of the effort to implement PIMS and discussing some possible extensions of PIMS. Two appendices are included. The first presents brief descriptions of the major databases currently maintained concerning DSN operations at Goldstone. The second contains copies of several of the forms used to collect data for those databases, and also examples of the outputs of some of them.

II. Motivation for PIMS

This section presents an overview of the motivations behind and objectives of PIMS. As noted in the Introduction, the expense of operating the DSN is considerable. Thus, implementation of efficient operational policies can lead to substantial savings and cost reductions. In this period of financial limitations and reductions, such savings gain even greater significance.

An important tool in developing these cost-saving policies is studying the current operation of the DSN. Indeed, as indicated in Appendix A, a wealth of data concerning DSN operations is being recorded each week, and much of it is publicized through periodic reports or is directly accessible. However, the different data sets are recorded and maintained for different purposes, and their overall characters reflect these differences. For example, the Barstow Production Control (BPC) database (A4 in Appendix A) stores the manhours expended on component repairs, retaining detailed manhour information for each component repaired. On the other hand, the Manpower Utilization Reports (A6), which record manhours expended in the actual operation of the antenna stations, list only the weekly totals of manhours expended in various categories. Thus, solely because of the nature of the actual data stored, it is inherently difficult to integrate information from the different data sets in a meaningful, useful manner. As a result, it is difficult to analyze this information from the perspective of reducing overall operational costs.

A second, distinct obstacle to integrating DSN operations data is that the various databases are stored in different formats and use different overall methodologies. On the one hand, some of the databases such as the Scheduling and BPC Databases, use sophisticated data storage and access routines written largely in assembly language. Others, however, such as the Manpower Utilization Reports and Transfer Agreement Status Database (A2) are really file management systems using simply formatted records. Data access for these is generally performed through the generation of a complete report rather than through response to a specific inquiry. And at the extreme, the Maintenance and Integration Work Orders (A5) are not stored electronically at all, but rather retained in their original hand-written form.

The PIMS effort is intended to be the first step in overcoming these two obstacles, in order that management scientists and managers can easily obtain integrated data concerning DSN operations. The uses of such integrated data abound. For example, the productivity, efficiency and expense of a wide variety of different activities could be determined and compared. Expenditures could be categorized in a variety of different ways to emphasize different aspects of DSN operations. (For instance, the total operational costs – including original investment, operations, maintenance, and component repair costs – of different subsystems or assemblies could be calculated and adjusted for relative usage rates, etc.). Comparisons could be made between the stations, and between past and present operational policies. Finally, the numbers computed from this integrated data could be used as the basis for a variety of cost-reducing statistical studies.

PIMS will also provide a second, distinctive type of access to integrated DSN operations data. Specifically, PIMS users will be given very flexible tools for iteratively manipulating the data in the systems. As a result, users will be able to interactively formulate queries which are based on the results of previous queries. Thus, it will be possible to interactively "explore" the data, and thereby discover anomalies or patterns of interest.

To illustrate the usefulness of such flexible access to integrated data in more concrete terms, we briefly mention the Remer and Lorden study conducted in the late 1970's (Ref. 2) The study analyzes data concerning the operation of DSS 13 in an automated mode during the latter half of 1978 in order to determine whether that automated mode resulted in cost savings. Discussions with the authors of this study indicate that obtaining the raw data underlying their analysis was difficult and time-consuming, and that the depth of the study was restricted as a result. It is anticipated that the initiation and maintenance of PIMS should partially alleviate such difficulties in future studies.

As currently envisioned, PIMS will be a narrowly focused pilot system with three primary objectives. These are (1) to provide access to integrated data concerning a limited portion of DSN operations, (2) to demonstrate the utility of a PIMS-like system, and (3) to provide practical experience in the use of such a system. Thus, while PIMS will address itself to only a portion of DSN operations, it is expected to provide a firm basis for designing a more comprehensive PIMS-like system in the future.

III. Overview of PIMS

We now discuss the overall capabilities of the (initial version of the) Productivity Information Management System. In broadest terms, PIMS will provide interactive access to data concerning the manhours expended at Goldstone by three different types of personnel (operations, maintenance and integration, and repair), and to data concerning "end user hours." PIMS users will be able to make direct queries to the database, and can also create and manipulate subsets of the data in a wide variety of ways. These access mechanisms will make it possible to (1) derive specific information, and (2) generate tables listing averages and totals for virtually any categorization of manpower expenditures. After this capability is fully developed, a mechanism for displaying these tables in a simple, easy to understand format may also be incorporated, as well as various statistical routines. Finally, a capability for investigating causal relationships may be added to the system.

A central theme in the design of the initial version of PIMS is to provide a simple, convenient user interface which allows users to perform virtually any manipulation on the underlying data sets, but which insulates users from the actual implementation details. In this manner, PIMS provides a powerful but easy to understand tool for performing virtually any data retrieval. To provide this capability, a major portion of PIMS is devoted to performing the routine and tedious detail work required in data processing as users specify various operations in a simple and abstract manner. Indeed, a major component of the preliminary version of PIMS is concerned entirely with such data management, and is completely hidden from the user's view. Specifically, this component performs the initial processing of raw data, which involves transforming data stored in a variety of different formats and locations into data all having uniform format.

A final general characteristic of the preliminary version of PIMS is the modularity of its design. This modularity will make modifications and expansions of PIMS capabilities a relatively easy and painless task. In view of the role of PIMS as a pilot, and also the possibility that the raw data available to PIMS may change over time, this is a particularly important feature.

IV. Overall Design of PIMS

In this section we consider the overall design of the initial version of PIMS as currently being implemented.

The global design of PIMS is shown in Fig. 1. The system has two primary modules, one for data input and one for data output. The data input module uses the raw data to generate files which contain records of a certain kind, called "event records." The data output module supports interactive access to these files of event records.

Event records are intended to store information concerning individual "events" involving the expenditure of manhours. Examples of events include the performance of a single preventive maintenance task, the repair of a single component, and the operation of a station during a tracking pass. Various parameters concerning events are stored in event records. For example, these include the type of activity, the number of manhours expended, the end-user benefited (if any), the subsystem and assembly involved (if applicable), and the preventative maintenance number (if applicable).

Referring to Fig. 1, we now describe in turn each of the modules and components of PIMS.

A. Raw Data

As mentioned in the previous section, PIMS will initially integrate data concerning manhours of three categories of personnel: (1) operations personnel, (2) maintenance and integration personnel, and (3) repairs personnel. Data concerning operations manhours will be drawn from the Weekly Histories compiled by the Data Processing Unit at Goldstone (in Appendix A, see A1) and the Manpower Utilization Reports (A6). Data concerning maintenance and integration manhours will be drawn from the Maintenance and Integration Work Orders (A5). Finally, the recently implemented Productivity Database (A4) will be used to obtain data on repairs manhours.

B. Data Input Module

The sole function of the data input module will be to transform the raw data into files of event records. This module will consist of three submodules, one each for the three types of personnel data used. Each of these submodules will have the capability of reading and processing raw data from the appropriate data sources. Thus the PIMS event files can be updated as new raw data accumulates.

C. Event Files

In its initial version, PIMS will maintain nine files of event records, three for each of DSS 11, 12 and 14, these being devoted to "operation" events, "maintenance" events and "repair" events. Data is separated according to station primarily to enhance efficiency – much of the raw data can most easily be processed one station at a time, and the separation will prevent the stored data files from becoming unreasonably large. Also, many data access requests are expected to distinguish between the stations, so data processing time will be saved.

To understand why data is separated according to personnel category, we note that although many event parameters (such as manhours and day-of-year) are shared by events of each category, other event parameters (such as end-user hours for operations events, or turnaround time for repairs events) are unique to a given category. Thus the separation of events permits more efficient storage of the data. It should be noted, however, that sets of events of different types can be readily combined by PIMS users (see below).

D. Data Output Module

The function of the data output module is to provide convenient interactive access to the event files. As currently envisioned, this module will provide a menu-oriented interface to users. Thus when the system is on, users will be presented a "menu" of possible commands to choose from. As a result, the system will guide users through the correct steps of a data accessing procedure, and hence be very accessible to novice users.

The commands which PIMS users can give via the data output module will give users the capability of directly manipulating files of events. Specifically, users will be able to create new files, select specific subfiles according to given parameter values (e.g., select all events with manhour value between 3 and 5 hours), sort files, and merge files (possibly containing different types of events). Also, capabilities to print out the contents of these files, and to calculate simple numerical summaries of them (e.g., list the total manhours expended, broken down by week and subsystem type) will be available. To accomplish this the data output module will provide users with a small set of "atomic" file manipulation commands which can be applied repeatedly to obtain desired files and results.

E. Reference Files

The final major component of PIMS is the set of files maintained for reference purposes. These will include, for example, a portion of the Transfer Agreement Status Database (Appendix A, see A2) which lists the numbers, three-letter acronyms, and brief descriptions of DSN subsystems and assemblies.

Another example is the listing of preventive maintenance numbers and their short verbal descriptions. Because the data in these files are modified occasionally, they are given a fairly independent status in PIMS. This will ensure that their modification can be incorporated in a simple straightforward manner.

V. Some Examples

In this section we briefly illustrate some of the capabilities that PIMS will have by describing three representative examples. Together they indicate the primary capabilities of PIMS as currently being developed; other capabilities will probably be added after the system is operational.

A. Table Generation

A basic capability of PIMS will be to generate tables summarizing information concerning various aspects of Goldstone operations. For example, suppose that a table is desired which lists, for the period June 1 to August 1, 1981, the total number of manhours expended per week, broken into categories of tracking, preventive maintenance, corrective maintenance, and repairs. To obtain such a table, the following sequence of steps could be performed. First, since only the periods June 1 to August 1, 1981, are desired, nine working files could be formed, each consisting of the relevant portion of one of the permanent event files (see Section IV-C). Now these files could be merged into one, and sorted by day of year. Next, the resulting file could be partitioned into one-week blocks and, within each block, sorted according to work category. (This would have the effect, within each block, of placing all events concerning a given work category physically next to each other.) Having arranged the file in this manner, a routine can now be executed which calculates, for each week, the number of manhours expended within each work category. Finally, a table printing routine can be called to print the results on paper or display them on the screen.

All of the procedures described above will be implemented in a very flexible fashion in PIMS. Thus a table can be constructed that lists total manhours broken into virtually any categories. Other parameters can also be totalled (e.g., end-user hours or downtime), and other types of aggregate functions will be available (e.g., average instead of total).

B. Comparison of Productivity

A second application of PIMS will be to compare corresponding aspects of different parts of Goldstone activities. For instance, suppose that a comparison, between the three Goldstone stations, of the ratio of the manhours expended on preventive vs corrective maintenance is desired. To obtain this, a procedure similar to that used for generating tables can be applied. Specifically, the user can first create files, one for each station, which contain all events involving preventive or corrective maintenance. Next, these files can be used to determine, for each station, the number of manhours expended on the two categories of maintenance. The desired ratios are then easily calculated.

Since PIMS is capable of categorizing data in a large number of ways, it will be useful in making many different types of comparisons.

C. Iterative Manipulation of Files

Another basic feature of PIMS is that users will be able to manipulate working files in an iterative fashion. For example, suppose that the user created the table described in Section V-A, and noticed that repairs costs were considerably higher than the other costs. The user may at that point wonder whether this inbalance was peculiar to a given subsystem or occurred in all of them. Using PIMS, the user can sort the working file already obtained by subsystem, and then list for each subsystem the number of manhours expended in each of the specified work categories. If interested, the user may then refine the data further, listing manhour expenditures categorized by assemblies within one or more subsystems.

It is clear that this kind of iterative, ad hoc file manipulation capability will provide users a means to literally "explore" the data in any way they please.

VI. Concluding Remarks

We conclude by describing the current status of the PIMS effort, mentioning some possible future directions for it.

At present, the overall design of the initial version of PIMS is essentially complete. The routine for processing raw data concerning operations personnel (Section IV-A) has been implemented and debugged. Also, the module which performs basic manipulations of event files (Section IV-D) is essentially completed, and the module for handling the reference files (Section IV-E) is under development. The remaining modules include those for inputting maintenance and repair data and for driving the menu-driven user interface.

Once the system is in operation, it is expected that, based on their experiences, users will determine that certain capabilities should be added to PIMS. For example, certain new data sets, such as Discrepancy Report information (Appendix A, see A7), may be desired. Also, more complicated statistical capabilities may be desired. Finally, new ways of representing the data, e.g., using plotted curves to indicate one parameter as a function of another, could be added.

More generally, if PIMS proves to be a useful tool for managers and management scientists at JPL, the project may lead to a more substantial effort to provide access to integrated DSN operations data. Given a firm commitment from management, a more ambitious database management system might be devised to perform the same functions as PIMS, except in a much more sophisticated and complete manner. Indeed, the PIMS effort may indicate the desirability of incorporating, at a fundamental level, a PIMS-like capability into the data management component of the Network Consolidation Project.

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Bibliography

1. Fahnestock, R. J., personal communication.
2. Remer, D. S., and Lorden, G., "Deep Space Station (DSS 13) Automation Demonstration," *The TDA Progress Report 42-57, March and April 1980*. Jet Propulsion Laboratory, Pasadena, Calif. pp. 103-119, June 15, 1980.

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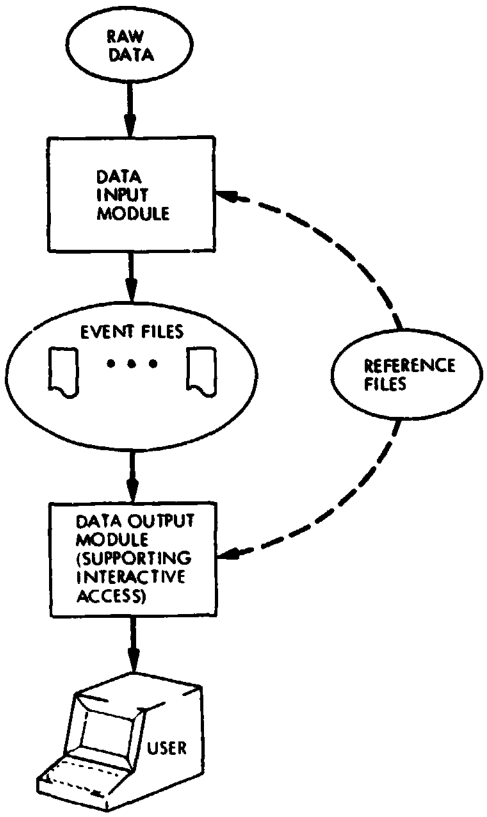

Fig. 1. Overall design of PIMS

Appendix A

Survey of DSN Operations Databases and Data Reports

The sheer size and complexity of the DSN has necessitated the development of several highly successful computerized information systems which are used to support its operation. In this appendix we briefly survey some of the more significant of these databases, and also mention a couple of related data sets (including an important database which has not been computerized to date). Table A1 provides a brief summary of our discussion. As noted above, PIMS will focus primarily on data in three of these databases (namely A1, A4 and A5) and make reference to some of the others (notably A2 and A6).

A1. The DSN Scheduling Database

The DSN Scheduling Database is maintained and used by Section 371 to schedule, on a week-to-week basis, the tracking activities of all of the DSN antenna stations. Roughly 500 to 700 events are scheduled for any given week, and events can be scheduled up to 53 weeks in advance. Once fixed, the actual schedule is used by the various DSN stations to plan, on a minute-to-minute basis, specific station activities (both those called for on the schedule and others such as certain preventative maintenance tasks). After a week has passed, Section 371 modifies the week's schedule to reflect the actual events of the week, and archives it as a weekly "history." These weekly histories form the basis of "DSN Utilization Reports," which summarize DSN activities, categorized by antenna size and end users. Independently, the Data Processing Unit of Bendix (in Barstow) updates the Goldstone portion of the weekly schedule and archives its own weekly "histories." These are used by the Data Processing Unit as the basis of "Station Utilization Reports," which are subsequently distributed by Section 371. These "Station Utilization Reports" list, for each station, the number of station operating hours (SOH) and end-user hours (EUH) devoted to each of the DSN "end-users" in the given week (see Appendix B for a sample report).

A2. Transfer Agreement Status Database (890-61)

The Transfer Agreement Status Database is concerned with recording information concerning engineering responsibility, from the station and facility level down to the subsystem and assembly level, of the DSN. For each station, subsystem and assembly it lists the subsystem engineer, the cognizant development engineer, the cognizant operations engineer and the cognizant sustaining engineer (if applicable), and the current status of these responsibility assignments (e.g., transfer planned, transfer complete). This database is stored at JPL's Information Processing Center (IPC) on the Univac 1100/81, and is maintained by Section 355. It is updated as needed to reflect assignments and transfer status changes. A variety of accessing modes to this database, each generating a report of a certain kind, is available.

An important aspect of the Transfer Agreement Status Database is that it provides information cross-referencing various naming conventions which have arisen for describing parts of the DSN. Each station can be viewed as consisting of roughly 25 "subsystems," and each subsystem is broken into roughly 10 "assemblies". Some subsystems are common to more than one station while others are unique to a specific station. Generally, a given subsystem or assembly can be identified in each of the following three ways: (1) the name of the subsystem or assembly (e.g., "34M. Ant Mechanical S/S" or "Electronic Control Assembly"), (2) the three-letter acronym, which sometimes extends to six letters (e.g., ANT or SVO), and (3) the two- to four-digit two-level hierarchical identifier (e.g., 46.00 or 46.02; here the first (two) digit(s) refer to the subsystem while the latter digit(s) refer to the assembly within the subsystem). The Transfer Agreement Status report provides a correlation between these three modes of identification and specifies which subsystem and assemblies are relevant to a given station.

A3. DSN Equipment Database

The Equipment Database is a large-scale database management system implemented on the Univac 1100/81 and maintained by Section 377. It holds data concerning all of the actual physical components comprising the DSN. The database is used primarily for inventory control and component tracking and also to support ad hoc operations performance analyses and answer various ad hoc queries. The database currently holds some 170,000 records and grows at a rate of roughly 1000 records per week. It lists, for each DSN component, a variety of information, including its unique identifier (called the "DSN control number" or "conaudit number"), description, manufacturer identification number, current location, and information concerning its repair history. The database can be accessed through a versatile interactive command language which supports multikey retrieval and totally flexible format specification. The database can also be interfaced directly by computer software.

A4. Barstow Production Control Database

Quite recently, a new computerized database system has been implemented to monitor and control the flow of DSN components through the repair facilities at Goldstone. This Barstow Production Control (BPC) Database is in the final stages of implementation in Section 377, and will be maintained (and possibly enhanced) by that section. The database will store very detailed records concerning each instance where a DSN component was repaired, including various dates, what specific activities were performed (including procedure numbers, if applicable), which DSN test equipment was used, and how many manhours were spent on various activities (Appendix B shows an example of a "Service Report," which can list all of the information stored in one record of this database).

The database is housed on the Univac 1100/81, currently holds roughly 15,000 records, and is growing at a rate of approximately 1000 records per month. In its current implementation the database provides sophisticated data compression, and also indexing to provide fast access according to certain data fields. Data is put into the system via computer terminals, and records are updated as various stages of repair, testing or calibration are completed. The system can be accessed by a flexible, command-oriented query language, both online and in batch mode. At present the output of this database is formatted identically to the Service Report.

The BPC Database replaces in part another comprehensive database, the Failure Database, which was maintained by Section 377 until April 1981. That database was used to maintain records concerning component failures, and stored a failure history for each component. The database was partially integrated into the Equipment Database, and data could be accessed through a number of data fields. Whereas the Failure Database was used to monitor repair activity and store a comprehensive history of each substantial component, the BPC Database at present only monitors individual instances of component repair.

A5. Maintenance and Integration Work Orders

An important database concerning DSN Goldstone operations which is not currently computerized concerns the activity of the Maintenance and Integration (M&I) Unit (of the Bendix Corporation) at Goldstone. This unit is responsible for performing a large class of routine preventive maintenance activities, trouble-shooting station problems, removing and replacing components, and performing some of the work generated by Engineering Change Orders. This activity is monitored and directed via "Work Orders" (see Appendix B), which are used (1) to specify that a given task is to be performed, and (2) to record the work that was performed, including manhours expended (and beginning recently, the amount of time used in transportation). Although the current system used by the M&I unit to record its activity is certainly adequate, it is clear that a computerized system would enhance the ability to obtain interrelated data and overview information, thereby improving the unit's overall performance.

A6. Manpower Utilization Reports

The Manpower Utilization Reports are generated on a weekly basis by the Tracking Operations and Data Processing Units (of the Bendix Corporation) at Goldstone and Barstow (respectively). These reports give a weekly summary of the operations personnel and M&I personnel manhours expended at Goldstone, broken into roughly 20 categories (see Appendix B). Note the distinction between Manpower Utilization Reports, which list manhours expended, and the DSN and Station Utilization Reports (discussed in A1 above), which list station operating hours and end-user hours.

The Manpower Utilization Reports are assembled from the "shift reports" kept at each station (at Goldstone) and by M&I (see Appendix B for a blank copy of Shift Report) and stored in the Sycor minicomputer maintained in Goldstone by the Data Processing Unit in Barstow. Quarterly and annual summaries of this information may also be generated upon request.

A7. Discrepancy Report Database

The Discrepancy Report Database is maintained by Section 371 to monitor "discrepancies." A discrepancy is defined to be an instance in which an end-user was scheduled to receive telemetry data, and received either degraded data or no data. Thus, discrepancies are initially "generated" when an end-user reports such data degradation or loss. Once a discrepancy has occurred, it is considered "open" until the cause of the discrepancy has been located (and if applicable, remedied).

The Discrepancy Report Database is maintained in an IBM 3032 computer managed by the Administrative Computing Service (ACS) at Caltech. The database is used to store and update records concerning open discrepancy reports, and has records of past discrepancy reports going back to 1975. It is also used to determine operational "Mean Time Between Failures," system trends and distribution of problems by hardware, software and procedural anomalies. Finally, special software routines can be used to answer ad hoc queries made to the database.

A8. Engineering Change Management (ECM) Database

The ECM database is used to monitor the implementation status of Engineering Change Orders (ECO) in the DSN. These data include a description of the change, its application and various milestones/status reports during the development, shipment, and facility installation and testing of it. Periodic management reports are generated and some ad hoc queries are supported in predefined formats. The system was originally implemented in 1976, is housed in the IPC and is managed by Section 377. It should also be noted that before approval, information concerning Engineering Change Requests (ECRs) is maintained in AODC word processors.

A9. System for Resources Management (SRM)

Although not dedicated solely to DSN operations, we briefly describe the System for Resources Management. The SRM provides the backbone for accounting activities at JPL. It is used to monitor all JPL income and expenditures, to coordinate future expenditures against future income, and to record past income and expenditures. The SRM is capable of formatting and summarizing accounting information in a variety of ways, producing reports such as the Resources Status Report (RSR), and the SRM planning summaries. Also, interfaces between the SRM and the WADSUM (see A10) have been developed. At this time, the SRM is not an interactive system – updates and modifications to the data must be done in batch mode, and only after a special processing of the entire data set is performed can the (newly revised) data be printed out.

The SRM is housed in the ACS IBM 3032. As well as containing data for the current year, it stores detailed records for the past 4 years and archived records for earlier years. Also, it contains information concerning projected expenditures for the next 5 years. The database is quite large; it holds roughly 200,000 records for a current year, and at present the primary history file holds another 320,000 records.

A10. The Work Authorization Document Summary System (WADSUM)

This system was developed to fulfill reporting requirements regarding planned TDA resources allocations. The database, resident on the IPC Univac 1100/81, contains headcount and expenditure data for each account in the TDA program. The database is composed of 1500 records, and may be accessed and updated either interactively or in batch mode. Numerous sorting and report writing capabilities are supported.

Various interfaces exist between the WADSUM and the SRM. For example, a WAD performance report, generated monthly on the ACS IBM 3032, details the discrepancies between the "planned" manpower and funding levels in the WADSUM database, and corresponding accrued "actu" recorded in the SRM data bases.

The WADSUM system was developed and is maintained under the cognizance of the TDA Program Control Office.

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Table A-1. Database summary

	Name	Section	Original implementation	Residence	Primary objectives	Secondary usage(s)	Accessibility
A1	DSN Scheduling	371	1965	IPC	Facilitate scheduling of DSN tracking activities	Basis for station operations. Basis for various "utilization" reports and for weekly "histories"	Schedules generated at various intervals. Other access almost exclusively restricted to direct scheduling activity
A2	Transfer Agreement Status Database (890-61)	355	1975	IPC	Store current engineering resp[illegible]ibility assignments for DSN	Correlation of subsystem and assembly nomenclatures	Several alternative report generating capabilities
A3	DSN Equipment Database	377	1975	IPC	Inventory control of DSN equipment	Operations performance analysis. Ad hoc questions and analysis	Versatile interactive command language for item specification and listing. Direct software interface available
A4	Barstow Production Control Database	377	1981	IPC	M[illegible]itor and control flow of DSN components through DSN repair facilities		Command-oriented query language; output to (hard copy) "service report" and to terminals
A5	Maintenance and Integration Work Orders	M&I Unit at Goldstone		Goldstone (hard copy)	Monitor and control M&I activity		Hard copies stored in sequence at Goldstone. Subsets of data independently maintained by cognizant engineers
A6	Manpower Utilization Reports	Tracking operations and data processing unit at Goldstone and Barstow	1978	Goldstone (Sycor minicomputer)	Report summaries of manpower expended by operations and M&I personnel		Reports generated weekly
A7	Discrepancy Report Database	3[illegible]	1966	IBM 3032 at Caltech	Monitor discrepancies		Ad hoc queries answered using special software routines
A8	Engineering Change Management (ECM) Database	377	1976	IPC	Monitor engineering changes to DSN		Interactive access to facilitate processing and monitoring of engineering change orders. Summary report generation
A9	System Resources Management (SRM) Database	632	1969	IBM 3032 at Caltech	Schedule and monitor JPL financial accounts		Report generation; ad hoc queries; interface to WADSUM
A10	Work Authorization Document Summary System (WADSUM)	410	1972	IPC	Fulfill NASA reporting requirements regarding planned resource allocations		Interactive access; interface to SRM; report generating capabilities

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Appendix B

Examples of Schedules and Reports

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DSS-14 STATION UTILIZATION REPORT
FOR
WEEK 5, 1981

I. DSN USER SUPPORT	SOH	EUH	PER
A. 1. SPACECRAFT TRACKING			
PIONEER-7	6.17	4.83	3.67%
PIONEER-9	5.25	4.50	3.13%
PIONEER-10	14.17	12.17	8.43%
PIONEER-11	7.92	6.67	4.71%
PIONEER-12	16.42	13.42	9.77%
VOYAGER-2	13.67	10.67	8.13%
2. PROJECT RELATED SUPPORT			
VOYAGER	6.00	3.00	3.57%
3. DSN PROJECT PREPARATION			
DSN	2.75	2.75	1.64%
B. RADIO SCIENCE			
OSS	11.67	10.92	6.94%
C. ADVANCED SYSTEMS			
D. SPECIAL			
SUB-TOTAL	84.00	68.93	50.00%
II. FACILITY ACTIVITIES			
A. MAINTENANCE			
1. PREVENTIVE	25.75		15.33%
2. CORRECTIVE(DOWNTIME)	41.75		24.85%
3. CORRECTIVE(NO DOWNTIME)	0.00		0.00%
B. PERSONNEL TRAINING	1.08		.64%
C. DSN ENGINEERING			
1. ENGINEERING SUPPORT	15.42		9.18%
2. DEVELOPMENT OR TESTING	0.00		0.00%
3. MINOR MODS	0.00		0.00%
III. OTHER ACTIVITIES			
A. MAJOR MODIFICATIONS	0.00		0.00%
B. HOST COUNTRY RADIO SCIENCE	0.00		0.00%
C. MISCELLANEOUS	0.00		0.00%
TOTAL HOURS	168.00	68.93	100.00%

****

Fig. B-1. Station Utilization Report (Data Processing Unit, Goldstone)

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DSN 7-DAY OPERATIONS SCHEDULE
ACTIVITIES LISTING

WEEK NO. 12 *** 22 MAR 82 - 28 MAR 82

LINE ITEM	DAY	START END	FACILITY	USER	ACTIVITY	PASS NO.	PRE-TRACK HRS-MIN	AOS-LOS	POST TRACK HRS-MIN	DSS CONFIG	WORK CATEGORY	DSN CONFIG
TUE 23 MAR												
78	82	1730-1800	DSS-12		PM 40-04-2-0-02	NIB	NONE	1730-1800	NONE	ARMSTR	2A1	B700
79	82	1740-0205	DSS-14	DSN	NRB SSI TEST	NIB	NONE	1740-0205	NONE	1A2		D700
80	82	1810-1935	DSS-63		TRAINING		NONE	1810-1945	NONE	NONE	2B1	M700
81	82	1935-0310	DSS-63	VGR-01	TKG PASS	1665	1 C	2035-0310	NONE	6B1192	1A1	M000
82	82	1935-1740	GCF	DSN	DSN TRACK LOOP	GCF	NONE	1935-1745	NONE	MAU		B09M
83	82	1935-0310	GCF	VGR-01	GCF SUPPORT 1665	GCF	NONE	1935-0410	NONE	DSS-63		B00M
84	82	1935-2105	GCF	VGR-01	GCF SUPPORT 1665	GCF	NONE	1935-2105	NONE	DSS-63		B36M
85	82	2005-0310	GCF	VGR-01	GCF SUPPORT 1665	GCF	NONE	2005-0310	NONE	DSS-63		B36M
86	82	2005-0310	GCF	DSN	NRB SSI TEST	GCF	NONE	2005-0310	NONE	DSS-63		B17M
87	82	2035-0425	DSS-61	PN-11	TKG PASS	3283	0 30	2125-0410	0 15	000063	1A1	K000
88	82	2055-0425	GCF	PN-11	L/G GCF SUPPORT		NONE	2055-0425	NONE	DSS-61		B60K
89	82	2100-1300	DSS-42		STA UNMAN/MAINT		NONE	2100-1300	NONE	NONE		B700
90	82	2100-1300	DSS-43		STA UNMAN/MAINT		NONE	2100-1300	NONE	NONE		M700
91	82	2105-0310	DSS-63	DSN	NRB SSI TEST	NIB	NONE	2105-0310	NONE	NONE	1A2	M700
92	82	2220-2400	DSS-12		TRAINING		NONE	2220-2400	NONE	NONE	2B1	B700
93	82	2220-2400	DSS-12		ECO 80-134	NIB	NONE	2220-2400	NONE	ARMSTR	2C3	B700
WED 24 MAR												
94	83	0000-0800	DSS-18	DSN	ECO 79.204 INST	NIB	NONE	0000-0800	NONE	ABICHA	2C3	B700
95	83	0000-0800	DSS-12		STATION UNMANNED		NONE	0000-0800	NONE	NONE		B700
96	83	0000-0800	DSS-12		ECO 80-134	NIB	NONE	0000-0800	NONE	ARMSTR	2C3	B700
97	83	0310-1520	DSS-14	VGR-02	TKG PASS D D/L	1682	1 30	0440-1420	1 0	69U092	1A1	D000
98	83	0310-0710	DSS-63	VGR-02	DELTA DOR		1 30	0440-0640	0 30	NONE	1A2	M30C
99	83	0340-0640	DSS-13	6STD6	A/S MK4 RMET DEV		1 C	0440-0640	NONE	VGR-02	1C1	C600
100	83	0340-1520	GCF	VGR-02	GCF SUPPORT		NONE	0340-1520	NONE	DSS-14		B600
101	83	0340-0640	GCF	6STD6	A/S MK4 RMET DEV	GCF	NONE	0340-0640	NONE	DSS-13/14		B26C
102	83	0340-0640	GCF	VGR-02	DELTA DOR	GCF	NONE	0340-0640	NONE	DSS14/14/63		B14C
103	83	0340-0640	GCF	VGR-02	DELTA DOR	GCF	NONE	0340-0640	NONE	DSS63/14/14		B14M
104	83	0425-1430	DSS-61	PN-12	TKG PASS	1405	0 30	0455-1400	0 30	800063	1A1	K000
105	83	0425-1430	GCF	PN-12	L/G GCF SUPPORT		NONE	0425-1430	NONE	DSS-61		B60K
106	83	0710-1210	DSS-63		MAINTENANCE		NONE	0710-1210	NONE	NONE	2A1	M700
107	83	0800-0830	DSS-12		STATION CHECK		NONE	0800-0840	NONE	NONE	2A1	B700
108	83	0840-1300	DSS-12	PN-11	TKG PASS	3283	0 30	0900-1245	0 15	000063	1A1	B000
109	83	0840-1300	GCF	PN-11	L/G GCF SUPPORT		NONE	0830-1300	NONE	DSS-12		B60B
110	83	1210-1805	DSS-63	PN-10	TKG PASS	3684	0 30	1240-1745	0 20	000063	1A1	M000
111	83	1210-1805	GCF	PN-10	L/G GCF SUPPORT		NONE	1210-1805	NONE	DSS-63		B60M
112	83	1230-0520	GCF	DSN	DSN TRACK LOOP	GCF	NONE	1230-0520	NONE	CAN 96		B09C
113	83	1300-2205	DSS-12	PN-12	TKG PASS	1406	0 30	1330-2150	0 15	800063	1A1	B000
114	83	1300-2205	GCF	PN-12	L/G GCF SUPPORT		NONE	1300-2205	NONE	DSS-12		B60B

Fig. B-2. (Portion of) Weekly DSN Operations Schedule (Section 371)

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SHIFT REPORT

DSS ________ Date: ____________ 197

Crew Supervisor ________ ________________ Crew _____ DOY _____ From _____ to _____ (GMT) Shift ________

PERSONNEL

Absent							Assigned Station Personnel					
Sick	UPB	Vac	Loan	School	Comp	Other	Crew	Other	Total Present	Man-Hours	Station Opns Hours	End User Hours

DSN USER

Support ______ Mission & Spacecraft No. ______ Pass No. ______ Cat. ______	.	.	.
Support ______ Mission & Spacecraft No. ______ Pass No. ______ Cat. ______	.	.	.
Support ______ Mission & Spacecraft No. ______ Pass No. ______ Cat. ______	.	.	.
Support ______ Mission & Spacecraft No. ______ Pass No. ______ Cat. ______	.	.	.

FACILITY MAINTENANCE & DEVELOPMENT

Maintenance Preventive	2A1	.	.
Maintenance Corrective (Down Time)	2A2	.	.
Maintenance Corrective (No Down Time)	2A3	.	.

Training 2B1 Name	Type: TM	TI	LPO	Other	Description	Instructor		
							.	.
							.	.
							.	.
							.	.
							.	.
							.	.
							.	.
							.	.
							.	.

Engineering Support	2C1	.	.
Development/Testing	2C2	.	.
Minor Modification	2C3	.	.
Major Reconfiguration	3A1	.	.
Miscellaneous	3C1	.	.
(SOD Initials ______)	Totals	.	.	.

RECORD OF EVENTS

GMT	EVENT

Fig. B-3. Shift Report for antenna stations (Tracking Operations Unit, Goldstone)

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WEEKLY MANPOWER UTILIZATION REPORT

GDSCC TRACKING STATIONS

WEEK ENDING 22 NOV 81

PROJ OR TASK	WORK CODE	DSS-11 NUMBER OF PERSONNEL=14 MAN HOURS THIS WEEK	DSS-11 % TOTAL MAN HRS THIS WEEK	DSS-11 % TOTAL MAN HRS YEAR TO DATE	DSS-12 NUMBER OF PERSONNEL=14 MAN HOURS THIS WEEK	DSS-12 % TOTAL MAN HRS THIS WEEK	DSS-12 % TOTAL MAN HRS YEAR TO DATE	DSS-14 NUMBER OF PERSONNEL=14 MAN HOURS THIS WEEK	DSS-14 % TOTAL MAN HRS THIS WEEK	DSS-14 % TOTAL MAN HRS YEAR TO DATE
HELIOS-1	1A1	134.8	24.4%	14.6%			2.7%			.2%
HELIOS-2	1A1			< .1%			.2%			.1%
PIONEER-10	1A1				133.5	25.1%	1.1%			9.4%
PIONEER-11	1A1			13.9%	30.6	5.8%	2.9%			3.2%
PIONEER-12	1A1	175.3	31.8%	16.3%	15.2	2.9%	5.3%			7.4%
VOYAGER-1	1A1			4.1%	82.6	15.5%	8.6%			1.6%
VOYAGER-2	1A1			2.6%	108.4	20.4%	21.8%			14.0%
VIKING-1	1A1			< .1%			.1%			.2%
PROJ REL SUPP	1A2	29.5	5.3%	3.3%	20.0	3.8%	7.3%	92.0	16.3%	13.4%
DSN PROJ PREP	1A3	11.0	2.0%	2.0%	15.0	2.8%	1.7%	4.0	.7%	1.6%
RADIO SCIENCE	1B1-4	16.6	3.0%	1.3%						2.0%
ADVANCED SYS	1C1,2									2.5%
OFFICE OF APP	1D1			.9%						.2%
PREVENT MAINT	2A1	128.6	23.3%	17.2%	87.1	16.4%	19.5%	72.0	12.8%	9.6%
CORR MAINT	2A2			.6%			.4%	338.0	59.9%	11[illegible]
CORR MAINT	2A3						.3%			.4%
PERS TRAINING	2B1	24.2	4.4%	15.6%	23.6	4.4%	8.7%	30.0	5.3%	5.5%
ENG SUPPORT	2C1			.2%			.2%	16.0	[illegible]	.5%
ENG SUPPORT	2C2						.8%			2.3%
MINOR MOD	2C3						.1%			.4%
MAJOR MOD	3A1						7.7%			1.7%
MISC	3C1			.1%			< .1%			.6%
ADMIN				.8%			1.6%			3.3%
ABSENCE		32.0	5.8%	5.9%	16.0	3.0%	7.1%	12.0	2.1%	6.9%
FIRST AID TNG				.5%			1.1%			.1%
EYE EXAMS				< .1%			< .1%			.1%
SAFETY				< .1%			.1%			< .1%
OTHER PROJ										
PIONEER-6	1A1									.7%
PIONEER-7	1A1									.4%
PIONEER-8	1A1									.2%
PIONEER-9	1A1						.5%			.5%
DSN ISEE	1A1						.2%			
STATION TOTALS		552.0			532.0			564.0		
M&I TOTALS		211.5			403.0			888.5		
OVERALL TOTAL (HRS)		763.5		25,302.5	935.0		28,453.1	1452.5		42,404.1
		DSS-11			DSS-12			DSS-14		

Fig. B-4. Manpower Utilization Report (Data Processing Unit, Goldstone)

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WORK ORDER

DSS ______ PRIORITY ______ SUBSYSTEM ______

NUMBER 44721

ORIGINATOR	EXT
DATE	ORIGINAL DATE
TECHNICIAN(S)	
WA REVIEW ☐	P.M. No.

Emergency	☐	EER No.
Unscheduled	☐	DR No.
Training	☐	ECO No.
Other	☐	
Scheduled	☐	DOY
From (GMT)		To (GMT)

Description of Trouble or Service Requested:

Instructions:

Work Performed

TIME	
Start	
Finish	
No. of Persons	
Total Manhours	
CLEAN-UP	☐
Configuration	☐
Check-Out	☐
INITIALS	
S.O.D.	
Crew Supv.	
M & I Engr.	
M & I Supv.	

Follow Up Action Required

Completed by	Date

ORIGINAL

Fig. B-5. Work Order (Maintenance and Integration Unit, Goldstone)

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SERVICE REPORT

TYPE [redacted] NO [redacted]

DSN CONTROL NO [redacted] CAT [redacted] PRIORITY [redacted] FOR DMC [redacted] CMF [redacted] SHOP [redacted]

FROM FAC DATE IN [redacted] DUE OUT

TRAVELER SHP NO [redacted] COMPLEX MEMO NO REQ NO

INCOMING INSTRUCTIONS

IN INSPECTION

SERVICE REQUIRED STORAGE LOCATION [redacted]

OIL SAMPLE ANALYSIS OPERATIONAL CHECK REPAIR CALIBRATE

MODIFY PER ECO [redacted]

SERVICE OVERHAUL IN ACCORDANCE WITH [redacted]

RE TM/DOC

SERVICE PERFORMED

IP INSPECTOR [redacted]

EQUIPMENT IS NOT SERVICEABLE

SEND TO VENDOR FOR REP MOD EXC

NO REPAIR OR CAL REQUIRED. EQUIPMENT TESTED GOOD

SUSPENDED WORK FOR

STORAGE LOCATION [redacted]

	ON	RESUMED WORK		ON	RESUMED WORK
PARTS			DOCUMENTATION	[redacted]	[redacted]
TEST EQUIPMENT			DMC ENG SUPPORT		
RECRYSTALIZATION			JPL ENG SUPPORT		
			OTHER		

REQ. NO. REQ. DUE DATE

REPAIRED SERVICED/OVERHAULED IN ACCORDANCE WITH

MODIFIED PER ECO

ANALYZED

CALIBRATED

CALIBRATION DATA

CONDITION RECEIVED IN TOL OUT OF TOL FAILED

ADJUSTED YES NO FULL SPEC. LIMITED SPEC.

PROCEDURE NO

DSN CONTROL NOS OF TEST EQUIPMENT USED DURING CALIBRATION ACTIVITIES

STD CAL INT RECOMMENDED INT NEXT DUE DATE

DATE SERVICE ACTION COMPLETE TECHNICIAN FN INSPECTOR

SERVICE TIME

HOURS

TST ANL ___.__

REPAIR ___.__

MOD ___.__

CAL ___.__

TOTAL .

FINAL DISPOSITION

RETAINED AT DMC CMF STORAGE LOCATION

SENT TO ORIG FAC

SENT TO DLF

SENT TO ___ FOR DYNAMIC TEST

SENT TO

SENT TO VENDOR REP MOD EXC WARRANTY YES NO

SCRAPPED

TRAVELER NO SHIPPER NO DATE

COMMENTS

CHANGED (MODEL PART NO etc.)

DATA ENTRY COMPLETED DATE INI

JPL 6311/DSN(6/81)

Fig. B-6. Service Report of Barstow Production Control Database (Section 377)