DSN Energy Data Base Preliminary Design

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This article describes the initial design and implementation of a computerized data base created to support the DSN Energy Conservation Project with data relating to energy use at Goldstone Deep Space Communications Complex. In addition, it briefly gives the results of development work to date and identifies work currently in progress or in the planning stage.

I. Introduction

The Deep Space Station facilities consume a significant amount of energy, for which the last few years have been the focus for energy conservation. Crucial to any endeavor to reduce energy consumption is the acquisition and maintenance of relevant information. Prior to 1976, information was manually acquired, handled, and processed. In response to limited human resources and considering the emergence of a Centralized Management Data Base System (the DSN Data Base), the DSN Energy Conservation Project commissioned the creation of a computer-based energy data base whose preliminary design was implemented in 1976.

II. The Goldstone Energy Data Base

The concept of an energy data base was conceived from the growing awareness of the need for a readily available and easily accessable source of information relating to the use of energy resources. Initial attempts to gather data for energy studies being conducted at the Goldstone Deep Space Communications Complex (GDSCC) were frustrated by the degree of effort and length of time required to locate and research information. This illustrated the desirability of creating a formal, centralized data base which would provide:

(1) A readily available source of technical and descriptive data.

(2) A central, standardized reference to augment engineering analysis and design.

(3) Information for effective energy management.

(4) A historical record for comparison of actual performance with project goals.

(5) Information for preparing NASA Energy Program Reports.

Using these objectives as a guide, a preliminary energy data base was created and called the Goldstone Energy Data Base. It was implemented in November 1976 and contained sixteen files describing such Goldstone facility parameters as: building architectural construction, utilities, equipment loads, facility operations, and weather, as shown in Fig. 1. The data were collected and placed into a publicly accessable permanent catalog file on the GPCF Univac 1108 titled GOLDSTONE* ENERGY, and an accompanying user document was written and released to explain the design philosophy and provide user access instructions. One application for the data base was to

provide input data for certain engineering energy analysis and design computer programs such as E-CUBE, NECAP, and the Energy Consumption Program. These programs require information about building construction, operation, and equipment loads. A brief description of each file listed in Table 1 follows.

(1) The interior architectural files, ARC/100 and ARC/200, describe each room of the Goldstone buildings by its wall, floor, and ceiling dimensions, and their construction material U-factor (thermal transmissivity). Both files designate which zone of the building air conditioning system serves each room.

(2) The interior lighting file, INL/100, describes the number of room lighting fixtures and their loads in kilowatts. Both quantities are listed separately by flourescent and incandescent light fixtures. Lighting is also a heating load, which is imposed on a fixed zone of the building air conditioning system. Average light level in foot candles is identified as a requirement for the function and occupancy of the room.

(3) The interior occupancy file, OCC/100, lists the personnel capacity and actual occupancy for each room by eight-hour work shifts for week and weekend day types.

(4) The Interior Electrical Equipment Files, EEQ/100 and EEQ/101, provide a listing by room, number of racks, type of equipment, and total rack power load in kilowatts; also, there is a breakdown by rack of each piece of equipment giving subsystem name and number. Power load in kilowatts, and the corresponding heat dissipated, is given for various operational modes, which include normal station tracking operation, standby, and station closed.

(5) The Exterior Lighting File, EXL/100, describes lighting for the exterior area of each building, which includes number and type of light fixture on each wall, wall orientation, and power in kilowatts.

(6) The Building Airconditioning Plant Files, ACP/100 and ACP/200, identify and locate each air conditioning plant. Each major component is described by size, type and energy load. Air handler size is given in cfm and compressor size in tons. Power used by humidifiers, boilers, heaters, and condensor motors is expressed in kilowatts.

(7) The Power Plant Files, PPL/100 and PPL/200, describe and locate all diesel power plants at Goldstone. The number of frequency convertors, engine generators, and their respective power used or produced is listed.

(8) The Building Utilities File, UTL/100, designates all utilities entering each building, which includes, electrical power by voltage and frequency, telephone, public address, microwave facilities, LP gas, water, and sewer.

(9) The Weather Files, WEA/100, WEA 200, WEA 300, and WEA/400 describe dry bulb temperature, dew point temperature, cloud cover ratio, and wet bulb temperature, respectively. Each file consists of hourly values for each day of a statistically representative year.

III. Preliminary Design Requirements

Certain data base requirements were determined to be desirable by project management. For example, it was considered desirable that all data be "raw" data, due to the past experience of having difficulty in assessing the integrity of acquired data. This meant that, to the extent possible, data values should be directly observed, unconverted, and not derived via computation from other data.

Another requirement was that data should be entered into files in a format that would be human-readable, requiring no interpretive software to produce reports. In part, due to the limited size of the staff available for data base design and implementation, user application software was left to the user for development. Data base files were created on the Univac 1108 as system file elements. Thus they are compatible with MBASIC™ and FORTRAN Programming languages. Plus physical record length was constrained to a maximum of 80 characters to provide both system flexibility and a convenient terminal display format.

Recently, standard guidelines have been published for the design and implementation of data bases on the DSN Data Base System. This DSN Standard Practice document and the recent inclusion of the DSN Energy Data Base into the DSN Technical Facilities Subsystem is currently resulting in the reassessment of DSN Energy Data Base functional design requirements.

IV. Data Base Design

The Goldstone Energy Data Base is designed as a collection of hierarchically structured groups of files (as shown in Fig. 2). This design is intended to provide opportunity for data base growth with minimal structural limitations as well as providing flexibility in its eventual incorporation into the DSN Data Base System.

Data is divided into groups of files containing related data categories as shown in Table 1. All groups consist of one or more files that are structured into three levels: primary, secondary, and tertiary. Each level represents a breakdown of information or other relational association with the files in the

level above. The first file of each level is defined as the initial file. When the logical data record exceeds the maximum length permitted in the initial file, up to eight "continuation files" may be created to provide the required logical record length as shown in Fig. 3.

Files are labeled by a three-character acronym preceeding a three-digit numerical sequence. The acronym identifies the file group while number sequence indicates level and whether it is an "initial" or "continuation" file. File structure, shown in Fig. 4, consists of three record types. The first is the identification record containing information required to identify the file, companion documentation, transaction dates, and the individual responsible for data integrity. The second record is the header record, which provides column headers aligned over each data field that identify the respective data items. The remainder of the file is data records having the same format as established by the header record.

In accordance with design specification, application software was not developed. However, two interactive data access programs were written in MBASIC to provide the casual user with outputs of data base files. The program titled DISPLAY displays files on the users demand terminal while COPY-EG outputs to GPCF line printers.

Description of each file group giving narrative and file composition data was documented into a modularly organized users document entitled: "DSN Energy Project Data Base Facility Parameters for Goldstone". The document describes data base purpose and scope, design structure, description of each file group, and data access instructions. The modular construction of the document provides for addition of sections as new files and groups are added to the data base.

V. Current Status and Future Development

Several additional data categories have been added to the data base since its initial creation. The sixteen original files have grown to nearly thirty, and additional files are in the planning stage. This has resulted in five new groups as well as additional new files to existing groups. Figure 5 and Table 2 show the current and planned growth of the DSN Energy Data Base.

(1) The Energy Consumption Data Group (ECD) consists of seven files with five more in planning. This group lists individual readings from meters that measure consumption of LP gas, diesel fuel, gasoline, electrical power, and water. Also, monthly billing is listed for each respective type. Two additional files complete the group: one lists total monthly energy usage by energy type, and the thermal equivalent that enables the computation of Goldstone total energy consumption. The other is a cross-reference file, providing meter serial number, reading conversion factors, meter location, and installation dates.

(2) The Programmatic Energy Change Group (PGM) consists of three files which keep a historical record of NASA program related changes in energy usage at Goldstone. Such changes include installation or removal of equipment, variation in operational schedules, and operational duty cycle.

(3) The Energy Conservation Change Group (CON) is planned to keep a record similar to the PGM group, but relating to energy conservation actions.

(4) The Building Operation Mode Group (BOM) is still in the planning stage, but is expected to contain facility operational specifications and related data for each building.

(5) The DSN Data Base Interface Group is a special category of four files required by a recently published DSN Standard Practice document. These files, which are in the planning stage, will provide the user with a file catalog, listing files with a narrative description of their purpose and contents. The data dictionary defines each data item and describes its location, type, and size within the data file. The interface group becomes a part of a larger data base interface increment within the DSN Data Base System upon the implementation and transfer of the DSN Energy Data Base to that system.

Not only has the Goldstone Energy Data Base expanded, but there is consideration to extend the data base to include the Australian and Spanish Deep Space Communication Complexes, which would result in the creation of a DSN Energy Data Base.

As mentioned above, the energy data base is being defined as a group with the Technical Facilities subsystem, and considerable review of the data base functional requirements is expected. As a result of new requirements, coupled with the potential for automatic data acquisition suggested by the development of a Technical Facilities Controller (TFC), DSN Monitor and Control (DMC) Mark III, and the creation of the Configuration Control Assembly (CCA), which will contain the DSN Data Base, considerable change to the design of the data base is expected.

In the new design, an elementary data management system will be added consisting of data maintenance software, user access programs, and some applications software.

At the same time of the development of the Goldstone Energy Data Base, a Goldstone Facility Management Data Management System was designed, and an automated data system was implemented (see Ref. 2). This resulted in a Goldstone Facility Management (GFM) Data Base that, among other functions, collected facility energy consumption data for monthly reporting to NASA. The DSN Energy Conservation Project and Goldstone DSCC management decided that the GFM data base was duplicating the Goldstone Energy Data Base in the area of energy related files. Therefore, the DSN Energy Data Base will assume the energy related data management tasks of the GFM Data Base in the new design. This will require the development of some user application software to generate required NASA reports.

VI. Summary

The initial energy data base implemented for Goldstone DSCC provides information support to the DSN Energy Conservation Project. Recent events will lead to an enhanced and expanded data management system design that will not only fulfill these objectives, but may provide other applications for general facility administration and engineering when incorporated into the central DSN Data Base System.

References

1. Date, C. J. *An Introduction to Database Systems*, Second Edition, Addison-Wesley, Reading Mass., 1977.

2. Maiocco, F. R., Hume, J. P., Computerizing Goldstone Facility Maintenance Data for Management Decisions, *DSN Progress Report 42-32*, pp. 310-330, January and February 1976, Jet Propulsion Laboratory, Pasadena, Calif.

Table 1. Goldstone Energy Data Base Content (1976)

Group Name	File Number	File Type	Description
Building Air Conditioning Plant (ACP)	100	Initial primary	Plant and compressor type and size; kilowatts used
Building Air Conditioning Plant (ACP)	200	Continuation primary	Humidifier, boiler and heater type; kilowatts used
Building Utilities (UTL)	100	Initial primary	Electrical and Mechanical type and class
Exterior Lighting (EXL)	100	Initial primary	Location and number of fixtures; kilowatts used
Interior Architectural (ARC)	100	Initial primary	Wall dimensions and U-factor
Interior Architectural (ARC)	200	Continuation primary	Ceiling and floor dimensions and U-factor
Interior Electrical Equipment (EEQ)	100	Initial primary	Number of racks and kilowatts used per room
Interior Electrical Equipment (EEQ)	101	Secondary	Kilowatts used per rack, NDL number
Interior Lighting (INL)	100	Initial primary	Location and number of fixtures; kilowatts used
Interior Occupancy (OCC)	100	Interior primary	Actual occupancy by room; capacity by room
Power Plant (PPL)	100	Initial primary	Station power plant frequency converters
Power Plant (PPL)	200	Continuation primary	Station power plant engine generating power
Weather (WEA)	100	Initial primary	Dry bulb data; Hourly
Weather (WEA)	200	Continuation primary	Dew point data; Hourly
Weather (WEA)	300	Continuation primary	Cloud cover data; Hourly
Weather (WEA)	400	Continuation primary	Wet bulb data; Hourly

Table 2. Additional DSN Energy Data Bank Contents (1979–1980)

Group Name	File Name	Description
Energy Consumption Data	ECD/100	Monthly LPG meter readings in gallons
	ECD/101[a]	LPG billing data
	ECD/200	Monthly diesel fuel meter readings in gallons
	ECD/201[a]	Diesel fuel billing data
	ECD/300	Monthly water meter readings in gallons
	ECD/301[a]	Water billing data
	ECD/400	Monthly electrical meter readings in kilowatt hours
	ECD/401	Commercial electrical power readings; SCE billing
	ECD/500[a]	Monthly gasoline data in gallons
	ECD/501[a]	Gasoline billing data
	ECD/600	Summary report of monthly total energy use; megawatt hours thermal
	ECD/610	Meter cross-reference between meter codes and S/N; installation and removal dates, meter locations
Programmatic Energy Changes	PGM/100	Summary report of kilowatt-hour changes in use
	PGM/101	Journal entry of duty-cycle and measurement code
	PGM/102	Journal entry of type and load change
Conservation Energy Changes	CON/100[a]	Summary report of kilowatt-hour changes in use
	CON/101[a]	Journal entry of duty-cycle and measurement code
	CON/102[a]	Journal entry of type load change

Table 2 (contd)

Group Name	File Name	Description
Building Operation Mode	BOM/100[a]	Building lighting and HVAC Operational Specifications
	BOM/200[a]	Building lighting and HVAC Operational Specifications
	BOM/300[a]	Building lighting and HVAC Operational Specifications
Data Dictionary	DIC/100[a]	Element name, file name, field length, position data type
	DIC/200[a]	Element definition, and relationships
File Catalog	CAT/300[a]	File name, purpose, and content

[a]These files have not been implemented (planning stage).

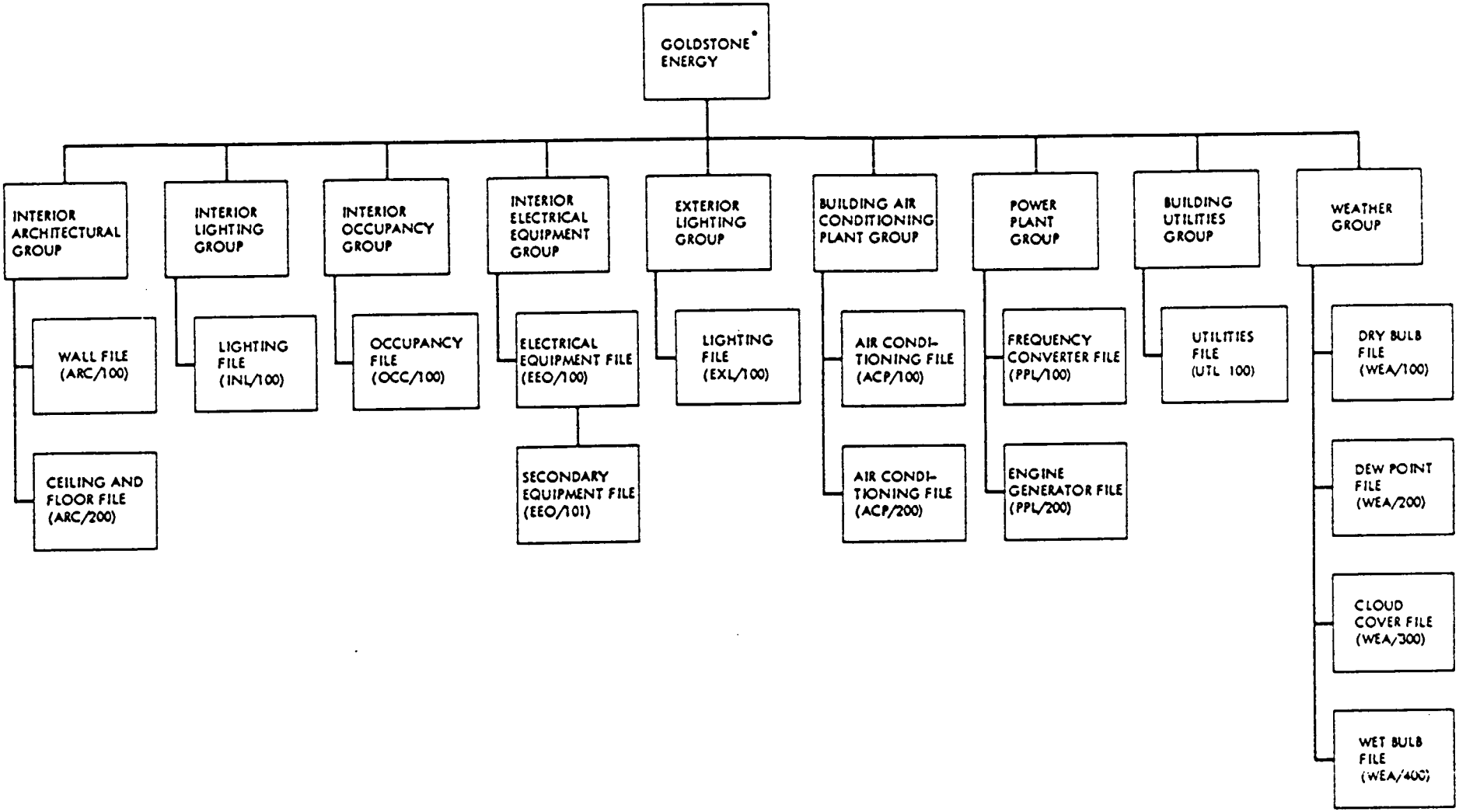

Fig. 1. Goldstone Energy Data Base (1976)

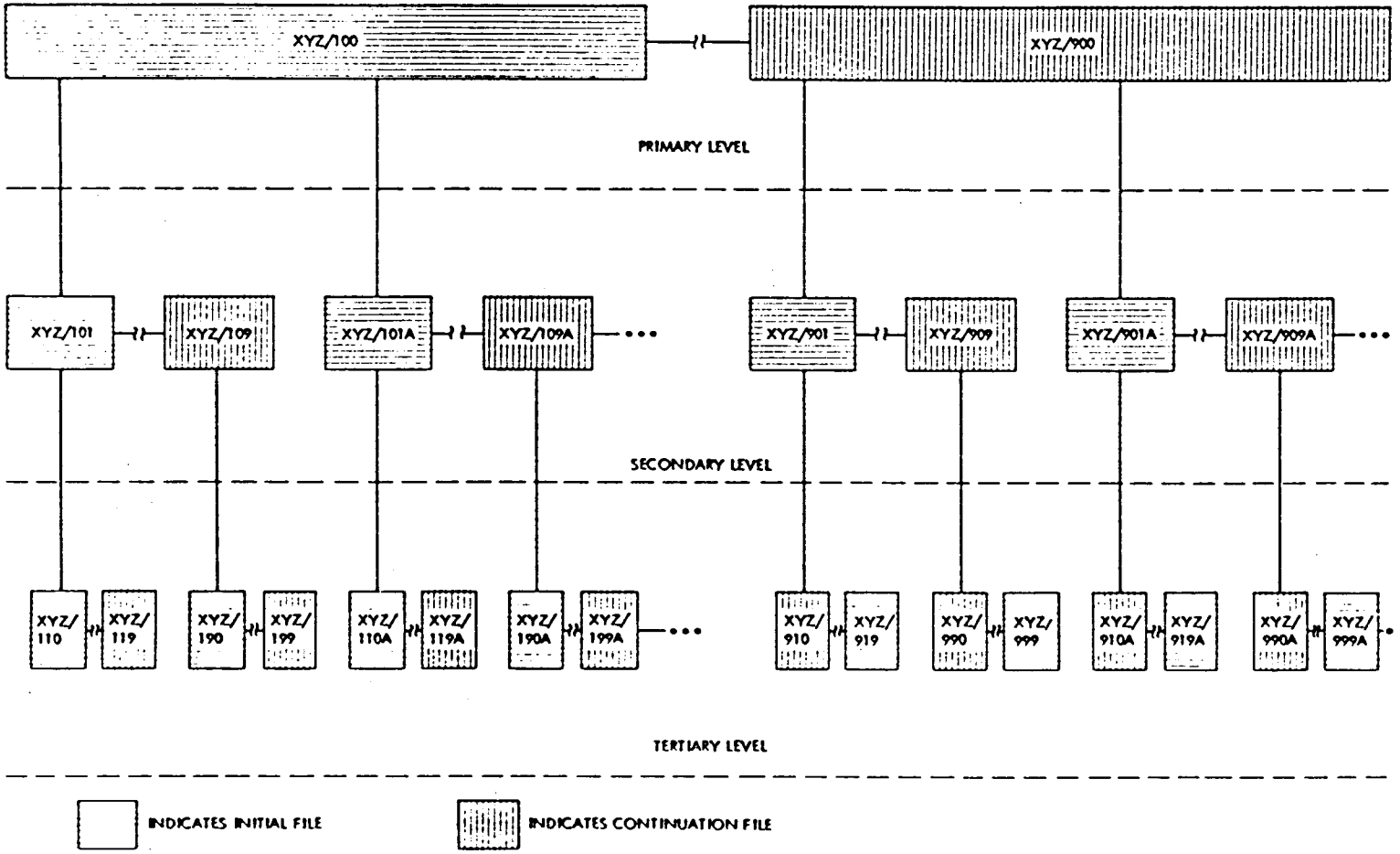

Fig. 2. Group structure hierarchy

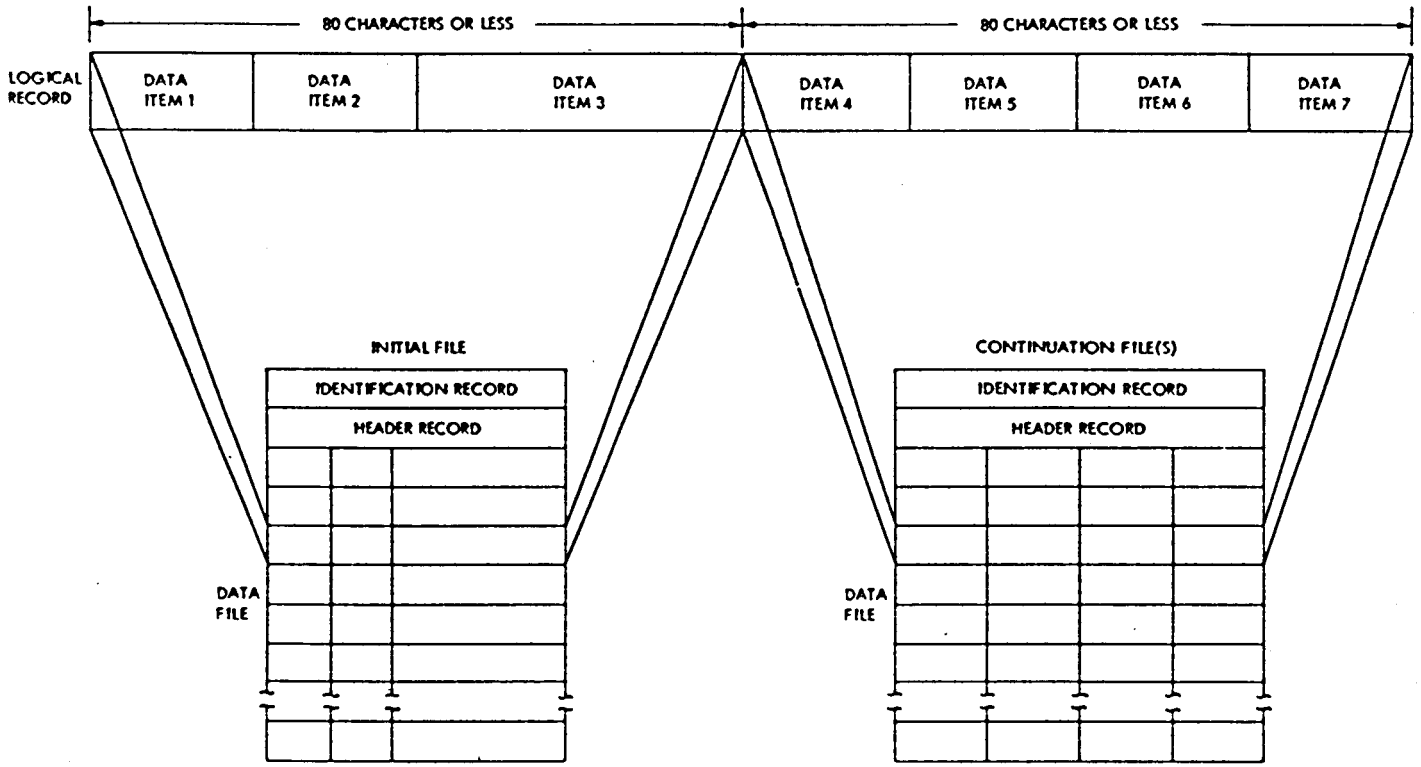

Fig. 3. Example of how a logical record is extended across physical file boundaries

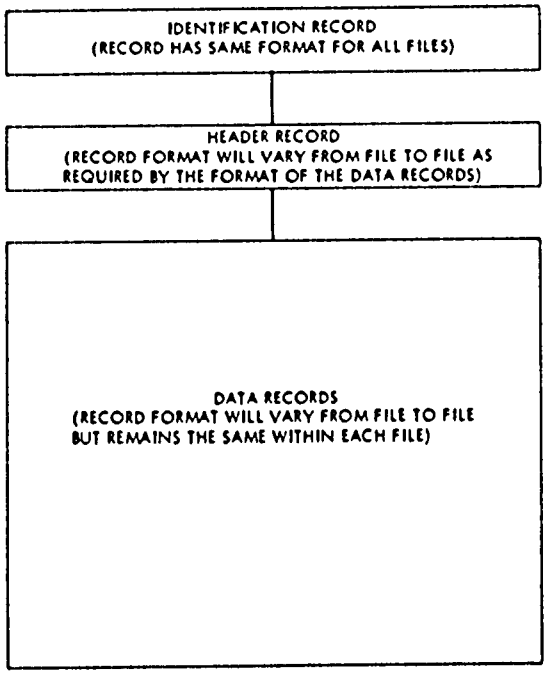

Fig. 4. File structure

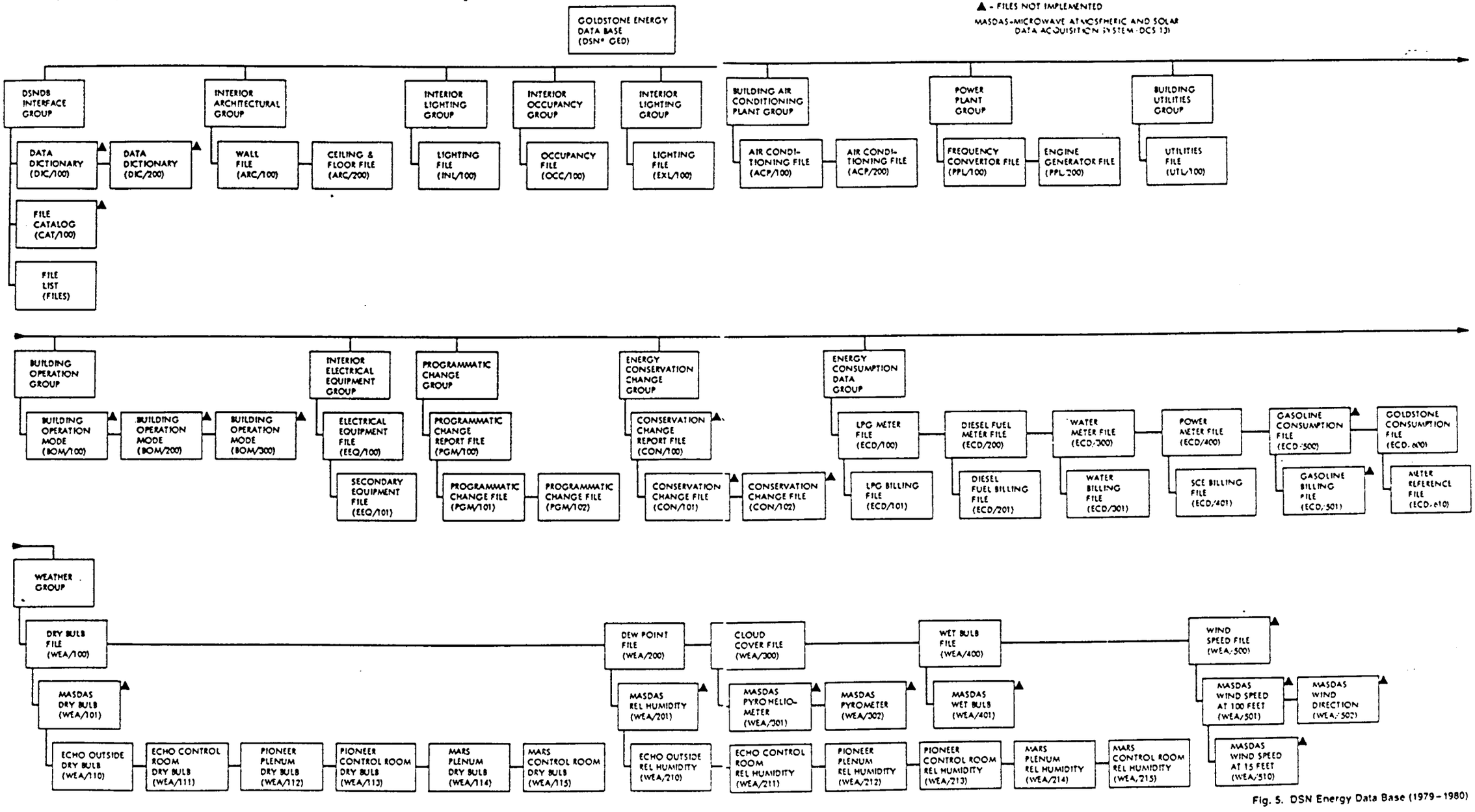

Fig. 5. DSN Energy Data Base (1979–1980)