

THE AMPTE CHARGE COMPOSITION EXPLORER SCIENCE DATA CENTER

The AMPTE Science Data Center at APL is a facility that supplies the computing needs of U.S. science investigators in their support of the AMPTE mission. This well-focused purpose has given the Science Data Center uniqueness and special characteristics in design, implementation, and operations.

INTRODUCTION

The AMPTE (Active Magnetospheric Particle Tracer Explorers) mission involves three spacecraft—the Ion Release Module (Federal Republic of Germany), the United Kingdom Subsatellite, and the Charge Composition Explorer (United States)—to be launched on a single Delta 3924 vehicle from the Kennedy Space Center in August 1984. The mission (described in detail in Ref. 1) will release and monitor tracer ions (lithium and barium) in the solar wind and within the distant magnetosphere to study access of solar wind ions to the magnetosphere and the processes that transport and accelerate magnetospheric particles. The instrument complement on all three AMPTE spacecraft is dedicated to making unified measurements that are necessary to meet the scientific objectives. For this reason, a concerted effort has been made to facilitate unified analysis by establishing a single science database for each spacecraft. The data reside in, and are distributed from, Science Data Centers in the United States, the Federal Republic of Germany, and the United Kingdom. The U.S. AMPTE Science Data Center (SDC) is being developed by The Johns Hopkins University Applied Physics Laboratory and is located there.

DATA SETS AND USERS

The Charge Composition Explorer carries five instruments: three particle instruments, a plasma wave experiment, and a vector magnetometer. The measurements from the instruments form a unified set in that their spectra overlap or are mutually supportive. They are unique in their data words, time/space synchronism, etc. but require many common supporting services and ancillary data.

The major advantage enjoyed by the U.S. AMPTE Science Data Center is that unlike a general-purpose computing facility, which must deal with a broad (generally unknown) spectrum of programs and data sets, the total number, size, and types of programs and data sets that are to be handled were generally known in the early stages of design. Further, identification of common support services (e.g., file archiving,

graphics production), processing steps (e.g., decommutation), and ancillary data sets allowed the development of SDC services that were tuned to these particular needs.

The data sets are mutually supportive and such ancillary information and services as current orbit ephemerides, spacecraft attitude, time reconstruction, etc. are common to all instruments. Therefore, placing the organization and storage responsibility of these files under a single authority significantly reduces the problems that invariably arise in directory updating, file purging, etc., when these tasks are performed by each user.

Much of the design and implementation effort has been directed toward identifying the boundaries between common and experimenter-specific data and responsibilities. Once identified, common data and services are placed under SDC control, the two advantages being to relieve the investigator of mundane, time-consuming tasks and to increase efficient use of the resources by reducing redundancy.

Not all choices are clear-cut. Generally, if a service is required by more than one instrument team, it is classified as common. However, there are tasks that everyone must do but that are not regarded as common, e.g., interpolation, transformation, and personal file creation. To satisfy such needs, a general utility library consisting of both purchased software and programs developed by the SDC (e.g., transformations) will be provided.

Our general aim is to provide the science investigator with a computing environment in which the requisite data and services are easily available so that the investigator's efforts are not diluted.

In summary, the Science Data Center user community consists of a group of about 20 scientists whose efforts are directed exclusively to the AMPTE mission. Individual and correlative studies are supported by a common database and common interests. Easy communication is not only a key to the scientific success of the mission but has been of immeasurable importance in the system development.

PROCESSING STRUCTURE AND HARDWARE CONFIGURATION

The design of the Science Data Center has been optimized to provide as many services as possible within the bounds of available time and money. We chose to target a facility where no more than half the resources would be consumed in performing the standard tasks associated with data collection and the processing necessary to provide a body of files containing clean, organized data and support information. This would leave adequate computing resources for detailed science analyses.

Figure 1 shows the general structure of Science Data Center processing. The major feature here is that the Center's staff is responsible for both creating and maintaining the measurement data and support information files.

Operationally, these tasks are driven by both real-time data during the active mission phases (and selected short data sets available when the spacecraft recorder is played back) and by recorded data that are recovered by the Jet Propulsion Laboratory and provided on a magnetic tape to the SDC. Two points are important:

1. The data acquired are a full coverage of the orbit, i.e., there are 3300 bits of data for every second the spacecraft is in orbit and operating.
2. All data are processed through this initial step.

Because the recorder is operating during real-time recoveries, dual data sets will exist for these periods (about seven weeks in total). The file generation is to be performed as a regular daily task by the operations staff. Current time estimates indicate that the tasks, in fact, will use our target value of about half the attended operations time.

The influence of real-time support is felt most strongly in the design of the decommutation and file creation processes. While the details will not be presented here, it is worth noting that they are data driven, that each experiment-specific processor operates at its own pace (i.e., data blocks that are meaningful to each processor are different from each other in volume and time boundary), and that the same processes are executed for both real-time data and recorded data, the latter being the faster of the operations.

The software required to create the data files is experiment specific, in part, and its development has been a cooperative effort between the SDC and experiment programming staffs. This is also the case with the hard products (graphics) output software, where the development is a cooperative effort and the production is an SDC responsibility.

As is often the case, the choice of the hardware configuration was difficult because of limited funding. We had some advantage in that the Charge Composition Explorer experimenters had flown similar instruments on other spacecraft so that some processing experience existed. Also, the user community was small and had

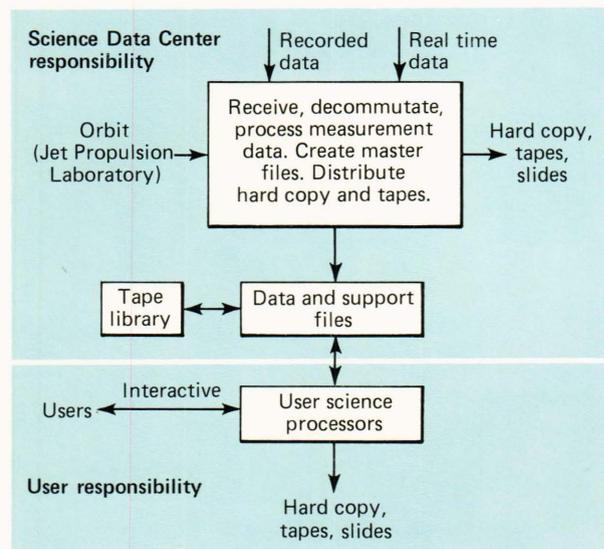


Figure 1—General processing structure showing the functions of the U.S. AMPTE Science Data Center. Note that users do not interact directly with the input data stream or with the tape library.

a well-defined common goal. As a result, the hardware configuration could be optimized to the specific needs of the experimenters.

The hardware configuration is shown in Fig. 2. The central computer is a Digital Equipment Corporation VAX-11/780 with 4 megabytes of memory, approximately 1.5 gigabytes of disk, and three high-speed tape drives. In addition, there are three high-speed (9600 bits per second) and six low-speed (300 to 2400 bits per second) communications modems connecting the input data lines and user terminals to the computer. A PDP-11/34 is used as the communications receiver and preprocessor for the real-time telemetry data transmitted to the SDC via NASA's communications network (NASCOM). The graphics production is performed using a RAMTEK 9453 and an associated matrix camera. A user room houses the color monitors and terminals for the APL investigators' program development and scientific studies and will be the science operations center during the active phases of the mission—the chemical releases by the Ion Release Module.

It was recognized at inception that an extensive and easily accessible off-line data/results library would be required. (The basic data rate, 35 megabytes per day, is coupled with a processing expansion ratio of about 8, which yields 280 megabytes per on-orbit day.) This has led not only to the high-speed, high-density tape drives shown but also to a critical partitioning of file space allocations on the disk.

The support information files (ephemerides, attitude, etc.) are relatively small, allowing spans of roughly a year to be maintained on disk. The master data file is very large (66 megabytes per day) and must be migrated to the tape library daily. The so-called pool file, which contains synoptic data, has been

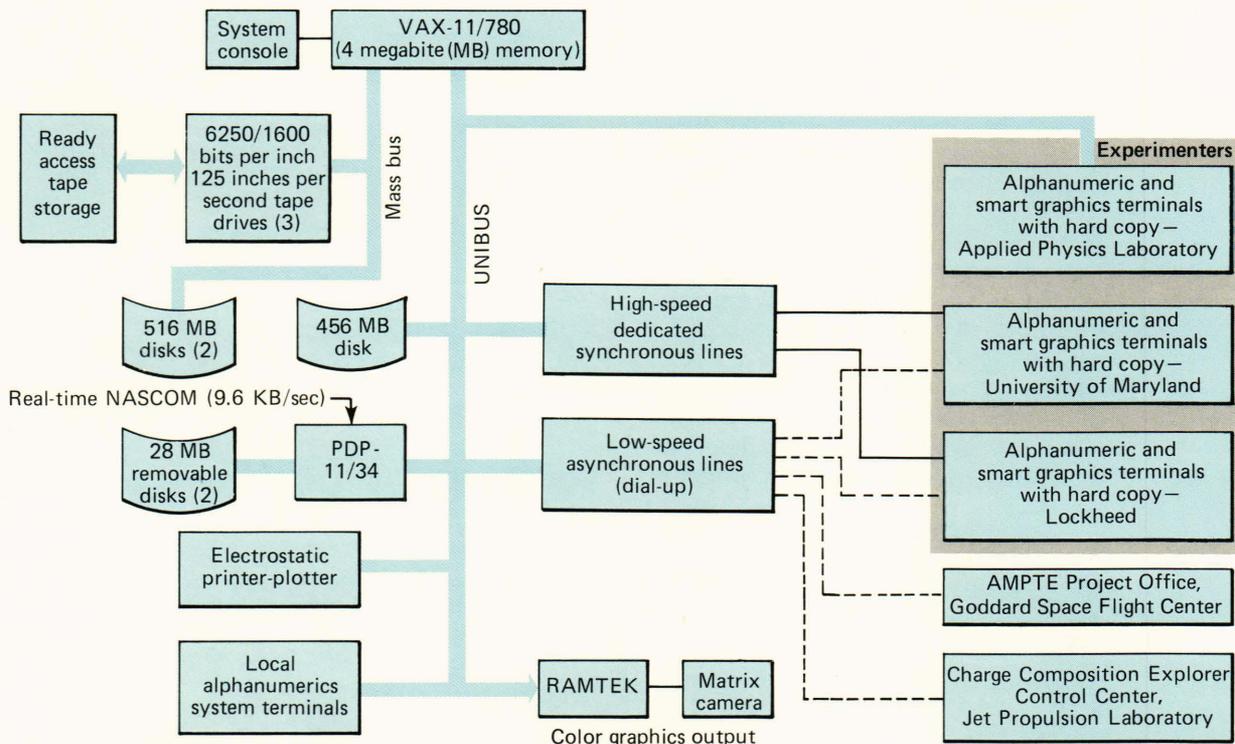


Figure 2—Block diagram of the hardware in the U.S. AMPTE Science Data Center and at the remote experimenter sites.

provided a large volume on the disk so that a 2-month span can be maintained on-line.

The general structure of access to files maintained by the SDC is shown in Fig. 3. The user access to these files is through SDC-provided read/write programs. This procedure makes the mechanics and media of storage transparent to the user. The SDC file maintenance consists of the mechanics of organization, directory updating, archiving, and promotion/demotion of files to and from the disk.

Investigator-specific files and processors differ from the SDC files and processors in that their operation, creation, and maintenance are completely under user control. Investigators are at liberty to use system service programs, but they are not required to do so.

In summary, there are two major contributions that a mission-unique computing center has to offer. First, the most effective application of resources is attained by maximizing capital equipment usage and minimizing required support staff. A computing facility dedicated to a single, well-defined mission can be optimized to meet these criteria and thereby get more for its computing dollar. Second, facilities like the AMPTE Science Data Center at APL represent a subtle philosophical shift from the traditional concepts of computing services. It is, in fact, a subsystem of the AMPTE mission; it performs a function with well-defined inputs and outputs. It not only serves as a computing center but is the communications connection for the experimenters with their instruments, with each other, and with the rest of the mission components.

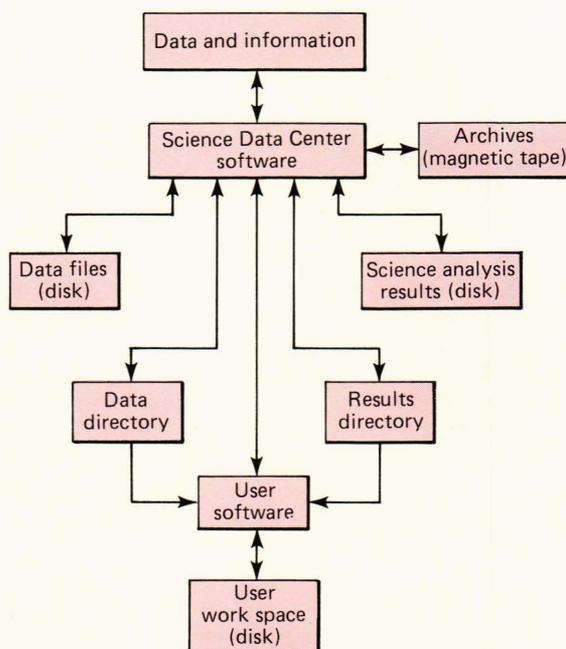


Figure 3—Structure of user access paths to the files and directories maintained by the U.S. AMPTE Science Data Center.

REFERENCE

¹ S. M. Krimigis, G. Haerendel, R. W. McEntire, G. Paschmann, and D. A. Bryant, "The Active Magnetospheric Particle Tracer Explorers Program," *Johns Hopkins APL Tech. Dig.* 4, 3-11 (1983).