Raymond J. Puhl
*NOAA National Geodetic Survey*
*Rockville, Maryland 20852*

# Storage and Retrieval with Microfilm

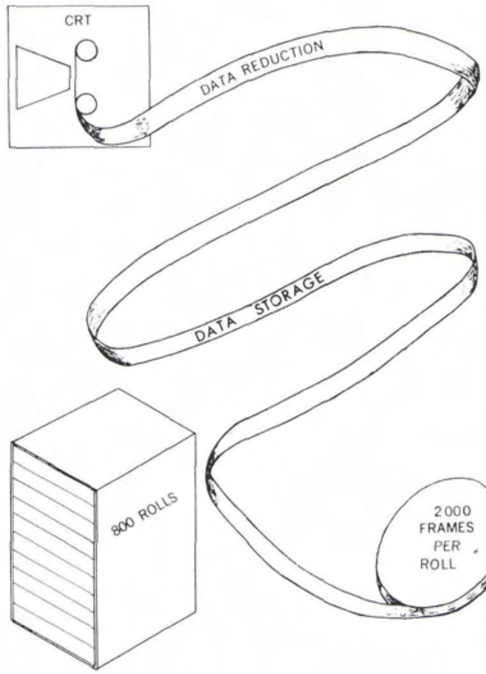


Fig. 1. Digital and graphic data are compressed into the form of 16-mm microfilm and stored in a compact space.

## Computer output is placed directly onto microfilm, the volume of data storage is reduced by a factor of 100, and hard copy of specific data can be obtained later.

*(Abstract on next page)*

### Introduction

The voluminous printed output created at computer installations has caused an ever increasing problem of producing the timely output demanded by its users. One solution to the input / output (i/o) problem is microfilm, which has the following features:

- Its output speeds are 5 to 30 times faster than impact printers.
- Storage space is reduced to 1/100 that of paper. One 100-foot roll of 16 mm film records from 1800-2400 pages (Figure 1).
- It offers storage stability if the film is processed properly. Because the work of The National Geodetic Survey involves geodetic control data, both continental and worldwide, these data must be stored indefinitely.
- Duplication is inexpensive, a duplicate roll of film costs three dollars. Hard copy varies, depending on the volume, from three to six cents per page if xerox copy is used.
- It provides a direct means of publication if data are recorded on 35 mm film. Printing-plate negatives can be produced directly from 35 mm film. Vitro Laboratories demonstrated this procedure in June 1971.
- Retrieval accuracy of microfilm for viewing depends on the inventory system's quality. Machine-readable film systems are still experimental, but hold the key to handling large data bases.

The enhancing features of microfilm systems thus should prove to be an effective alternative to on-line printers (Figure 2). Figure 1 & 2

### Background

Computer output on microfilm (com) had

its beginning in the mid-1950's, when the Naval Weapons Laboratory at Dahlgren, Virginia, and Stromberg Carlson (now Stromberg Data Graphics) joined forces to develop the 4010 cathode-ray tube (*CRT*) recorder. This early machine was used to record computer output on 35 mm film. The machine had a number of unique features. It could display graphics along with standard computer output listing. The system configuration was designed to operate in-line or off-line environment with their IBM 7030, 360/40, or 1401.

Computer-generated graphics were introduced to the National Ocean Survey in December 1962, when a 12-inch Calcomp Drum Plotter was attached to the IBM 1620. This equipment was purchased by the Seismology Division and was used to plot seismic data. In early 1964, the Satellite Triangulation program started using the plotter to display the residual patterns from least squares solutions in two different forms:

- Histograms plots of residuals were plotted relative to the Gaussian distribution curve.
- Frequency plots displayed the residuals from the curve–fit of the passage of a geodetic satellite* with the $x$-axis representing time and the $y$-axis a deviation from a straight line.

The use of computer-generated graphics quickly became an important tool for the analysis of least-squares solutions. By the end of 1964, these plots were an integral part of the program's data reduction system and had placed a considerable workload on the IBM 1620. In early 1965, the plotting required more than 8 hours per day, which was about 35 percent of the computer's utilization. It was during this period, while changing over from the Weather Bureau's IBM 7030 to the Navy's IBM 7030 at Dahlgren, that knowledge of the existence of the *CRT* plotter came about. By late 1965, the generating of histograms and frequency plot graphics on 35 mm film was operational. The *CRT* system produced a savings in time, from 20 minutes to 30 seconds, and a reduction in cost, from \$10 per chart with the 1620 to \$3 with the *CRT*. In addition, the turnaround time was improved from several days to a maximum of overnight.

In the spring of 1966, another use for the *CRT* plotter became apparent. This advance in computer-associated equipment could be used as a data storage medium as well as a graphics generator, with capabilities of printing speeds up to 150 pages per minute in print mode. At this time, the fastest on line-printer was capable of only 12 pages per minute. As most computers are I/O bound from time to time, this feature should be of interest to both the user and the installation's management. An added bonus to the user is the reduction in storage space of 50 to 1 using 35 mm film for computer output.

A very generalized system was established to minimize the number of problems during implementation of the COM system. To accomplish this a control program was written for 360/40 which permitted the 7030 output tape to be recorded on film, using the CRT and requiring no changes to the existing application program. The FORCE control program had the ability to manipulate the CRT mode (print or plot). This feature permitted both printing and graphics for a particular solution to be recorded on a single strip of film. This reduced the amount of film splicing required to create the data base. Before the system could be made operational, the allotted time on the Dahlgren system was reduced for administrative reasons from four hours to one

ABSTRACT: *In connection with its world-wide satellite triangulation system, the National Ocean Survey applies a technique for recording computer output directly onto microfilm through the use of a cathode-ray tube data recorder. As a result, the volume of data storage is reduced by a factor of 100 compared to the volume of hard copy. The system incorporates the production of graphic histograms of residuals from least squares solutions directly onto the film during the process, the records can be studied with a film viewer, and hard copy of specific data can be produced if needed. The utilization of the system was developed over a period of four years.*

* A background description is contained in: Schmid, Dr. Hellmut H., "Accuracy Aspects of a World-Wide Passive Satellite Triangulation System," *Photogrammetric Engineering*, 31:1, pp. 104-123, 1965.

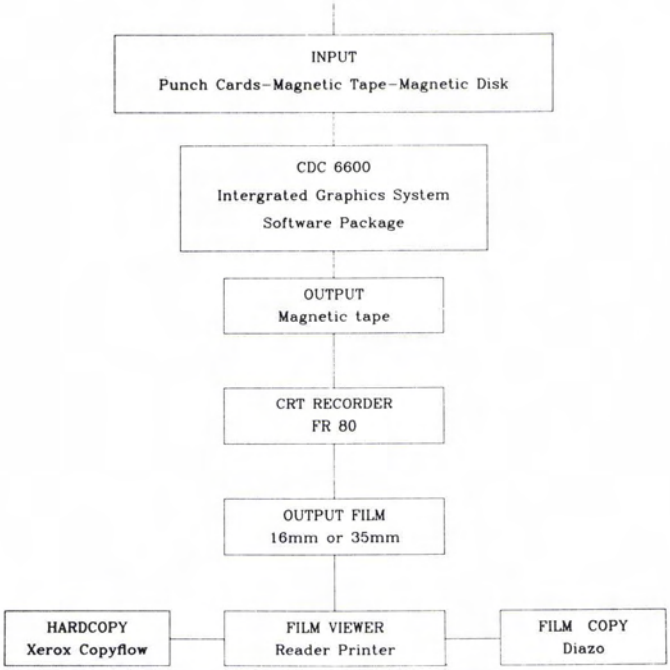


FIG. 2. Flow diagram showing the relative location of the CRT Recorder.

hour per day. This allowed only time enough to produce the graphics. This untimely change produced some problems. For instance, application programs had to be converted from the IBM 7030 to the CDC 6600, and another graphics device had to be located. The following time table gives the sequence of events which terminated when FR-80 (CRT) was installed at the NOAA computing center in Suitland, Maryland.

*July 1967.* An effort was made to obtain a CRT in-house, and a Bell Howell 16-mm camera was purchased to film computer output.

*May 1969.* The Assistant Administrator for ESSA Administration acknowledged that microfilm output should be provided by the ESSA Computer Division. An ad-hoc committee was established to study and make recommendations for obtaining a CRT.

*Sept. 1969.* The CRT committee submitted its findings. Two recommendations were made by the study group. ESSA should obtain a CRT system, and establish a contract with NASA for the use of their SD 4060 CRT located at the Goddard Space Flight Center.

*Oct. 1969.* A contract with NASA was consummated.

*Jan. 1970.* Two of the five data-reduction programs of the Satellite Triangualtion programs were operational and producing film.

*May 1970.* All five of the primary programs were operational and 33.3 thousand (K) frames were created that month. For the 10-month period of February-November 1970, the average monthly production was 50K with a low of 19K in February and a high of 4K in November.

*July 1971.* Information International's FR-80 was installed and was accepted about a month later on August 17.

The success of the COM system as a data storage medium in NOAA was the result of the efforts of many people. It had its inception in the Satellite Triangulation Program's data-processing areas, but without the combined efforts of the Geodetic Research Laboratory, the NOAA Computer Division Branches and the Assistant Administrator, it would still not be operational today.

The approach to the problem was an important factor. The Geodetic Satellite Program provided the model and support needed. It permitted the system to be designed, programmed and debugged using such low-cost rental systems as the Dahlgren SD 4010 and 4060 CRT's, and the SD 4060 at the NASA Goddard installation. These factors made the current CRT installation at Suitland a reality.

## CURRENT STATE

A review of the past six years of COM shows

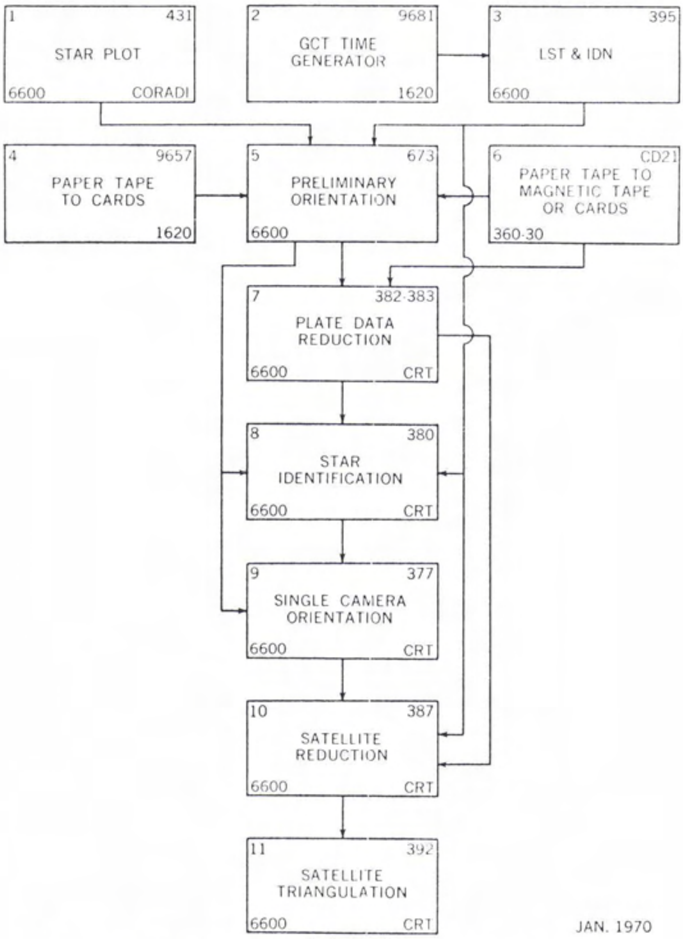


FIG. 3. Flow diagram showing 11 data reduction programs used in satellite triangulation.

that it appears to have been quite a successful system. The Satellite Triangulation Program's 1.5-million-page data- reduction effort is on 16-mm film. An effective computer-oriented update system for quick retrieval now exists. A means of inexpensive duplication of data to film is now available, and a 100 to 1 storage space reduction has been accomplished.

This system has the potential to do much more than just record data on film for future visual retrieval. A brief discussion of the current system should display its flexibility. The Satellite Triangulation Data Flow (Figure 3) presented the COM system with a variety of output problems. The numerous formats mixed with the graphics tested the versatility of the CRT system. The system was designed to handle a wide variety of print formats and a selection of data to be filmed from a multi-file tape. The standard 135 alpha-numeric columns and 60 lines per page was adopted and a special program was written for selecting the data to be filmed, converting output of the 6600 into the format required by the FR-80, and applying the Integrated Graphics System (IGS) of subroutines which converts 6600 output to CRT plot instructions.

The IGS system is considered a high-level computer language. By definition, it is a very flexible language as is demonstrated by the following characteristics:

★ An understanding of machine code is not needed.

★ One instruction generates a sequence of codes.

★ It is problem oriented, scientific or business type.

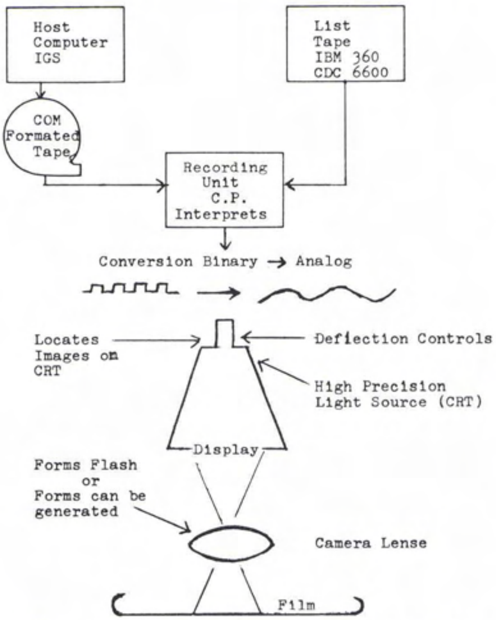


FIG. 4. How the Computer Output on Microfilm (COM) works.

★ The software package functions on various computers, because it is machine independent.

★ It provides flexibility by handling a variety of problems using its two modes of operation: print and plot.

IGS is Fortran-oriented, but may use Cobol, ALG, PL1 or any other language which is compatible with the subroutine linkage conventions. The purpose of IGS is to provide a comprehensive system which utilizes a library of subroutines to produce various graphic display functions. Using IGS, the computer can accept data and graphic-formulating instructions to perform scaling, conversions, and translations, then write an output magnetic tape in the meta-language required by the FR-80. This tape is the input to the recording FR-80.

The characters to be plotted may be generated using a charactron tube, which passes a beam of electrons through a stencil-like matrix, or by a hard-wired character set. Another technique available to the programmer is to plot the characters using a series of short-line segments to represent them. This latter technique permits the creation of special characters and an unlimited variety of fonts (Figure 4).

To maintain software flexibility, the FR-80 system has the ability to simulate a variety of impact printers as well as other plotters. These software packages will emulate IBM 360 and CDC 6600 series impact printers and will process virtually any format with no restrictions on the number of lines or characters per line. In addition, the simulator package will also process routine list tapes and require no changes in the host computer's software. The FR-80 has plotter simulator packages for the SD 4020 and 4060 CRT's, the Calcomp series of plotters, and various other recorders and plotters. These programs allow the user to record without having to reprogram. But, it must be pointed out that it is not as efficient as programs written for the specific FR-80 configuration.

Another important feature is the forms compiler. This permits the storage of forms in core for readout as needed by the recording programs. As the forms and data are controlled by the same system, exact registration and scaling can be obtained. This eliminates the problem of overprinting and also controls intensity and resolution. Up to six forms can be held in core. This would be helpful in the preparation of scientific data forms for general distribution. For the user with unique problems, the FR-80 has its own program language. It consists of a set of standard subroutines and application packages which should provide the user with all the routines to handle a particular recording problem. As is the case with most systems, the system configuration is quite flexible and has a proven performance, but lacks in documentation. The manuals supplied by the company leave much to be desired. However, the NOAA Computer Division's programming group has done much to eliminate this problem by supplying both verbal and written supplements to current documentation. In fact, they have entirely rewritten the graphics manual.

The purpose of the FR-80 system is to provide a medium for data storage and subsequent visual retrievals. For any system to be successful, it must be logical, economical, accurate, versatile and easy to use. As a visual storage medium, the FR-80 has measured up to the above requirements. To date, most of the applications of the CRT plotters have been directed towards the printing and graphing of scientific data and administrative records and the cartographic area has just started to utilize them. The drawing of both the special-purpose maps not requiring the national mapping accuracy standards, and routine maps for data completeness are currently being investigated.

### Conclusions

The discussion of retrieval has been limited to visual forms. When optical scanning (OCR) becomes both fact and economical, a solution to the problem of storing data bases will be available. Currently, the cost of OCR is about half that of key punching. Thus, it is worth the effort to use film as a backup to a magnetic tape, and its general application will depend on how well the industry presents its wares, and on the ingenuity and progressiveness of people in the various disciplines. At this time, their documentation leaves something to be desired; however, the CRT operation areas are helping to close the gap.

## ASP Remote-Sensing Symposium Draws Record Attendance

The ASP symposium on Management and Utilization of Remote Sensing Data held at Sioux Falls, S.D., October 29-November 1, 1973, was most favorably received. Hosted by the South Dakota Chapter of the ASP, USGS EROS Data Center, and the Sioux Falls Chamber of Commerce, the multidisciplinary meeting attracted approximately 600 persons including registrants from Japan, Indonesia, Italy, Mexico, Australia, West Germany, Canada, Soviet Russia and other foreign nations. Twenty-five companies exhibited a variety of equipment and services that were related to the symposium.

A warm welcome was accorded all attendees by the Holiday Inn Convention Center, as well as by the Mayor and townspeople of Sioux Falls, the Chamber of Commerce, and Governor Kniep of South Dakota.

The symposium began on Monday with tutorial sessions, followed by 60 papers presented during the next three days. Highlights included a luncheon keynote speech by Mr. E. A. Godby, Associate Director of the Canada Centre for Remote Sensing, in which he outlined the work being done on the ERTS program in Canada. The banquet speaker, NASA Astronaut Russell L. Schweickart, described many interesting experiences of the Skylab crew in space. Other highlights included tours of the nearby USGS EROS Data Center, and the Remote Sensing Institute of the University of South Dakota at Brookings.

The papers presented at the symposium covered a wide range of remote sensing subjects from the interpretation of ERTS-1 data to policing air pollution problems in Tokyo, Japan. Other papers were concerned with the automatic extraction of data, change detection, management of data, recording systems and sensing requirements data. One evening was set aside for informal discussions including a session on education, applications and global management of Remote Sensing.

As a result of excellent cooperation by the authors, the symposium editor was able to provide a copy of the 700-page proceedings to all attendees at the time of registration. Copies of the proceedings are available at Society Headquarters at a cost of $7.50 for members of ASP, AIAA, AEEE and AGI, and $12.50 for nonmembers. The interest engendered by the symposium resulted in acquiring almost 100 new members.

Participation by the American Institute of Aeronautics & Astronautics, the Institute of Electrical and Electronic Engineers, and the American Geological Institute was a major contribution to the success of the symposium.

*–Abraham Anson*
*ASP Reporter*