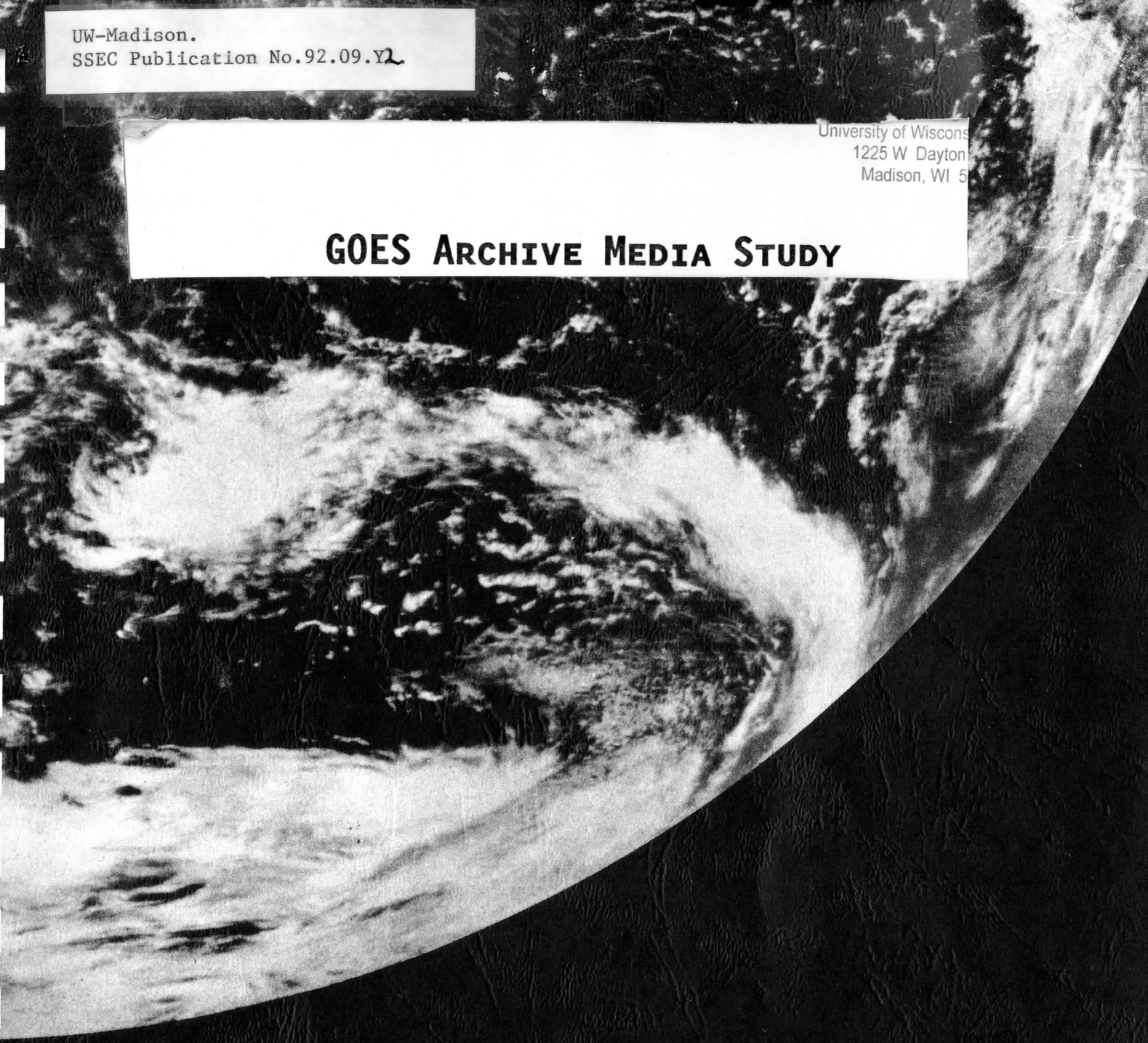
GOES ARCHIVE MEDIA STUDY



A REPORT

from the space science and engineering center
the university of wisconsin-madison
madison, wisconsin

GOES Archive Media Study

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I. SCOPE OF THIS STUDY

This study reports on a survey of the commercially available data storage media which might be used for the safe storage of the Geostationary Operational Environment Satellite (GOES) base archive data set. Included in the report is a description of each of the media considered, the recording devices, an analysis of the costs (fixed and variable), storage life issues, error correction, data transfer rates, storage requirements, and operational considerations. The report concludes with a recommendation for the destination media for the present effort, and a strategy for the long term storage.

II. CURRENT BASE ARCHIVE DESCRIPTION

A. General Background

The full resolution GOES archive system is operated by University of Wisconsin - Madison's (UW) Space Science and Engineering Center (SSEC) under contract to SDSD, and is based on unique GOES data handling and recording technology which was developed by SSEC in 1977-78.

SSEC has three GOES antenna/receiver systems for receiving the stretched VISSR transmissions from the operational satellites. The data are demodulated and recorded on 3M's 3/4" U-matic video-cassette tapes at high density by means of the technique described below. The data are stored at one of two sites. The most recent data, 1983 to the present, are stored within the SSEC building on the UW-Madison campus. The remainder are stored at the Wisconsin State Records Facility at another location in Madison, WI. SSEC uses an interactive display system, McIDAS (Man-computer Interactive Data Access System) to perform archive retrieval, data quality checks, navigation functions, on-line inventory creation, and to produce reformatted sectors on computer compatible and other media for distribution to the user community.

The GOES archive consists of about 27,000 3/4" U-matic tape cartridges, representing well over 115 terabytes (115 million-million bytes). Two recording densities were used over the life of the archive; a low density format providing up to 2.3 Gigabytes per cartridge and a high density format providing up to 4.6 Gigabytes. In addition, 2 tape lengths were used: 60 minute and 75 minute tapes.

1. Recording subsystem

The SSEC recording subsystem operates as a totally stand-alone system. The subsystem for each satellite consists of four recorders, four recorder electronics, a data logger, a quality control display, and a recorder switcher. The fourth recorder and electronics are spares. During operational recording, the switcher automatically routes the datastream to the next recorder when a tape nears the end. Thus the system runs unattended except for the daily tape replacement. In the event of a recorder or electronics failure, the spare unit can be easily switched into operation to replace the bad unit.

The data logger logs image start/stop times and various control parameters for use in building the inventory. The quality control display is used to verify the quality of the signal available to the recorders and to verify that a tape has been properly recorded and contains good data.

The cassette archive machine is a modified 3/4 inch U-matic Sony recorder that records digital satellite data. Except for high density machines, nothing mechanical is modified. The modifications for high density machines include the use of a separate electronics package specific to the signal. These electronics provide the servo reference timing, tape signal formatting/decoding, and the transport control functions.

High density operation doubles the recording density. It is accomplished by changing the scanner and slowing down the capstan another factor of two (beyond low density). High density operation eliminates the guard bands between head scans on tape. Azimuth recording allows separating the head scan information. The two scanner heads have different gap azimuths relative to the scan direction which allow independent magnetic tracks to be adjacent without interference. The slower tape speed changes the scan angle relative to tape allowing twice as much data to be recorded on the same length of tape. All recording is done at real time rates. That means the scanner and tape speed servos must be slowed down; for GOES low density, the factor is 3.6. The high density recording factor is 7.2.

Whenever units require replacing, the most recent Sony units are used. This keeps the recorder and player technology current with the industry, increasing the likely life of the archive.

2. Archive retrieval subsystem

The playback subsystem consists of a video cassette player, playback electronics, data switcher, search track display, and ingestor for the IBM mainframe computer.

The search track display allows the operator to quickly find the specific data desired on a tape. The data switcher allows the operator to couple specific players to specific ingest hardware and software, thereby providing maximum flexibility in using the system to service requests.

The cassette playback machine is a modified 3/4-inch U-matic Sony player that plays back digital satellite data. The modifications to the players are similar to the modifications made to the recorders. The playback electronics provide the servo reference timing, tape signal formatting/decoding, and the transport control functions.

An ingestor is a combination of hardware and software which receives the satellite signal (either real-time or played-back archive signal) and puts portions of the data into the McIDAS database. These data are quality checked by the McIDAS operators by visual inspection on a, as time is available, basis.

B. Media Description

Magnetic media are composed of many parts. Several on-going studies are addressing magnetic media archivability much more completely than will be attempted here. The three major components are the packaging, the underlying substrata, and the magnetic film.

1. Media packaging

Each 3/4" U-matic tape is contained in a cartridge 1"x9"x4 1/2" (similar to a standard VHS tape, only larger). This cartridge is stored in it's own polypropylene, closable case. Both the cartridge case and the storage case help protect the media from rapid temperature and humidity fluctuations, and particulate or pollutant contamination.

2. Substrata

The substrata is non-tensilized, meaning it tends to retain it's shape well. The substrata is susceptible to damage due to significant humidity fluctuations, but should be stable for at least 20 years, as long as the environment is reasonably well controlled.

3. Magnetic film

The magnetic film is Chromium-gamma-ferric-oxide. This magnetic film is not at all susceptible to oxidation (the iron is already in oxidized form). It is slightly susceptible to damage from pollution, but the case plus cartridge is sufficient to protect the media against pollution or particulate contamination.

C. Tape Handling Procedures

Once recorded and verified (QC'd), these cartridges are placed in their individual enclosures. Further protection is provided by placing 10 to 12 tapes in a tightly closed box. The boxing and unboxing is done at room temperature and humidity, thus protecting the tape from undue stress during transport to and from the storage facility.

Tapes removed for data retrieval or to sample the state of the archive are rewound but not retensioned before being returned. There is no process in place to routinely retension the tapes at this time.

D. Storage Facilities

There are three separate storage facilities. The state archive facility, which is adequately temperature and humidity controlled. Room 239 in the Space Science and Meteorology building, which is adequately temperature controlled but lacks significantly in humidity control. And the computer room in Space Science and Meteorology, which is adequately temperature and humidity controlled, but lacks adequate particulate control.

III. NATIONAL MEDIA LAB (NML) RECOMMENDATION

A. BACKGROUND

The National Media Lab (NML) is a Government supported Center of Excellence for Government recording programs. The Center is staffed with 46 employees and is partially funded by 3M.

The NML staff is working in five technical areas; media technology, advanced system concepts, theory and modelling, measurements, and operations support. The NML also includes the Magnetic Media Measurement Lab which provides media evaluation services to the Government.

The NML provides quarterly reports to the government, industry, and general public on the results of their media studies.

B. NML Recommendations

In January of 1990 a team from SSEC visited NML to discuss the GOES archive media and solicit recommendations from NML. The trip report for this visit is included as Appendix A. The NML recommendations are included in Appendix B. In summary, they recommend that the GOES archive continue on the present media (U-matic tape) since nothing as reliable is available on the market today. They further recommended that we plan to use the U-matic

system for the next 5-8 years. The new technologies are in considerable turmoil at this time. They all suffer from major problems from an archive point of view.

In addition, they recommended that:

1. The U-matic tape should be retensioned on the reel at 3-5 year intervals.

2. We keep recorders and playback unit close to the state of the industry for maintenance and spare parts availability.

3. We closely monitor tension on our present recorder and playback units.

4. We review tape handling and environmental conditions.

Temperature	70 degrees	+/- 5 degrees
Humidity	50%	+/- 5 %

5. We should annually reassess the state of the archive system industry by attending quarterly reviews.

Many of the new technologies are based on the requirements of the video recording industry which doesn't have a data archive requirement. The primary candidates in our investigation before visiting NML (D-2 and Exabyte) were strongly discouraged; both use tensilized, metal particle tape. For a discussion of the relevant issues see Appendix A.

IV. SURVEY SUMMARY TABLE

We have developed a summary table detailing the most pertinent information needed for a cost evaluation of candidate media. The table is included below. The total cost in the right most column is the sum of the media, drive and storage costs. No consideration was given to issues such as interrecord gaps, unique computer interface requirements, etc. The processing element needed for a complete system was also not included. The table has been sorted to show the least costly media at the top. The sources used for input to the table are detailed in Appendix C.

IV. SURVEY SUMMARY TABLE

23-Sep-92

Type of storage	storage cap. GB	drive cost $	media cost $	access time sec	transfer rate MB/sec	media quantity	media vol cu in	media vol/TB cu ft	Total Cost drives $ x1000	Total Cost media $ x1000	Total Cost 7 Yrs storage $ x1000	System Grand Total $ x1000
8mm tape Exabyte*	5.00	4,745	17	484	0.50	24,640	5.6	79	81	419	2	501
VHS cassette *	10.00	33,000	30	.5 ips	4.00	12,320	29.3	209	165	370	5	539
Sony U-matic (UW)	5.00	3,100	26	.5 ips	0.47	24,640	112.6	1,606	53	633	36	722
D2 drive *	25.00	200,000	35	55	15.00	4,928	112.6	321	600	172	7	780
digital instr. recorder	47.00	250,000	100	180	32.00	2,621	153.8	233	750	262	5	1,017
Ampex DST *	165.00	200,000	700	30	15.00	747	151.6	66	600	523	1	1,124
dat/dds*	2.00	1,500	20	20	0.18	61,600	3.0	105	60	1,232	2	1,294
optical tape (CREO)	1000.00	225,000	5,000	0.1	3.00	123	122.0	9	1,125	616	0	1,741
mag tape cartridge (3480)	0.43	45,000	5	75 ips	3.00	289,882	21.1	3,535	225	1,449	80	1,755
mag tape reel (6250)	0.18	22,000	8	75 ips	0.32	684,444	104.6	41,429	528	5,476	940	6,943
write once optical (12")	6.50	12,000	360	400	0.60	18,954	89.3	979	168	6,823	22	7,014
QIC tape	0.32	1,100	20	25	0.03	385,000	5.6	1,237	251	7,700	28	7,979
write once optical (14")	8.20	27,000	700	100	1.00	15,024	121.5	1,056	270	10,517	24	10,811
write once optical (5.25")	0.94	3,000	120	90	0.69	131,064	17.1	1,296	39	15,728	29	15,796
rewritable optical	0.65	5,000	230	95	0.68	189,538	3.7	411	65	43,594	9	43,668
rewritable optical	0.26	2,500	100	30	1.00	481,250	1.7	464	25	48,125	11	48,161
cd-rom	0.68	700	1,400	380	0.25	181,176	10.9	1,144	21	253,647	26	253,694

* Tensilized

V. ANALYSIS

In recommending a media for use in creating the archive copy, the first criteria we used was the "safety" of the data. Second, was the accessibility of the data in terms of the data rates, system longevity and system reliability. Third, was the total system cost over a seven year period.

NML provided much insight into the reliability and longevity issues. Based on their recommendations, all media candidates using tensilized tape were eliminated. These are identified with an * in the summary table.

Optical media are in their infancy. Even though data density and access speeds may exceed the current archive system, the longevity of the media has not been established. In the absence of a standard test for tape longevity or usage history, we believe the choice to use optical media would be premature.

Therefore, U-matic media remains the media of choice at this point in time. We are encouraged that a new media to replace the U-matic will become apparent over the next few years.

VI. RECOMMENDATIONS

It is the Government's and SSEC's goal to move the GOES data to a computer compatible medium. We recommend that we accomplish this in two stages. In the first stage, a copy is made of the U-matic archive tape onto the same media currently in use. Our experience with the U-matic tapes has demonstrated at least a twenty year life cycle for these tapes. Completion of this first stage means that we have a significant amount of time to decide on what medium will be used in the next stage. In the second stage the data will be written onto a suitable computer compatible medium (3480 optical or Exabyte show the most promise at this time).

A. Near Term Media Strategy

1. Destination media

Because of the proven longevity of the U-matic medium, we recommend following the National Media Laboratory's recommendation that we continue to archive data on this medium, and, generate a copy of the data on the same medium.

2. Error detection

The current SSEC archive system does not include any error detection or correction mechanism. We recommend that error detection capability be implemented so that degradation of the data integrity can be easily monitored. The current system of monitoring degradation by looking at displayed data is very costly, inefficient, and provides only a qualitative measure.

Implementation of error correction is not recommended because of the added complexity, considerable cost, and reduced processing throughput.

3. "Safe" storage plan

SSEC's plan to preserve the GOES archive includes generating a copy of the tapes. The copy would be used for all subsequent processing. Once the validity of the copy is verified, the original tape will be transported to a Federal archive facility, as yet unidentified.

B. Long Term Media Strategy

Based on NML's assessment, we expect to have a computer compatible medium suitable for use in a long term archive system available within about three to five years. We will monitor new technologies as they mature and evaluate promising candidates as identified in the NML's quarterly reports.

VII. APPENDICES

A. Appendix A. NML trip report

National Media Lab Trip Report
22 January 1991

Background

The National Media Lab (NML) is a Government-funded Center of Excellence for Government recording programs. It has a staff of 46. Provided by 3M. It is also partially funded by 3M.

NML provides quarterly reports to the government, industry, and general public. One day is allotted to the report, a second day is allotted to industry demos, and a third is a classified briefing for invited executives. The next report is scheduled for 29 January in McLean, Virginia.

NML is working in five areas; media technology, advanced system concepts, theory and modelling, measurements, operations support.

The NML includes the Magnetic Media Measurement Lab which is available to government users at no charge. NML also provides consulting and operations assistance at no charge. They will come to our site and take samples of our environment, evaluate on our tape handling, etc.

Attendees

Bill Callicott	NOAA/NESDIS
J. T. Young	UW/SSEC
Joe Rueden	UW/SSEC
Eric Suomi	UW/SSEC
John Boyd	USGS/EROS
Jay Feuquay	USGS/EROS
Ken Boettcher	USGS/EROS
Bill Mularie	NML/3M
Darlene Carlson	NML
Erin Binder	NML/3M
Gene Hickok	NML/3M
George Klechefski	NML/3M
Raj Patel	NML/3M

Summary

We presented a review of our current archive system and our requirements for the climate system.

NML recommended that:

> We stick with our present system, (U-matic tape) since nothing as reliable is available on the market today. They said that we should plan to use U-matic for the next 5-8 years. The new technologies are in considerable turmoil at this time. They all suffer from major problems from an archive point of view.

In addition, they recommended that:

1. The U-matic tape should be retensioned on the reel at 3-5 year intervals.

2. We keep recorders and playback unit close to the state of the industry for maintenance and spare parts availability.

3. We closely monitor tension on our present recorder and playback units.

4. We review tape handling and environmental conditions.

Temperature	70 degrees	+/- 5 degrees
Humidity	50%	+/- 5 %

5. We should annually reassess the state of the archive system industry by attending on of the quarterly reviews.

We were surprised that they didn't recommend a new media. Many of the new technologies are based on video recording industry requirements which doesn't have archive requirement. The primary candidates in our investigation to date (D-2 and Exabyte) were strongly discouraged; both require tensilized, metal particle tape.

The metal particles (iron) are very easily corroded and are moisture and pollution sensitive.

The tape is tensilized to 1,000,000 psi in the longitudinal direction, and 300,000 psi in the transverse direction. This is done to make the tape thinner and stiffer for better performance in the transport. The substrata polymers have a

memory and try to return to the original dimensions. Over time this dimensional instability changes the track to track distance, and data loss results. In some cases, dimensional instability has caused complete data loss after only six months.

These problems are present in most of the new formats:

DAT	8mm	Super VHS
D-1	D-2	Exabyte

Other points of interest:

There is no accepted definition of "archive" or "archive quality" by the industry, but any definition must include hardware and software as they frequently don't last as long as the media.

B. Appendix B. NML recommendations

NATIONAL MEDIA LABORATORY

P.O. Box 33015
St. Paul, MN 55133-3015

March 13, 1992

Attention: Mr. Joe Rueden
University of Wisconsin
Space Science and Engineering Center
1225 West Dayton St., Rm. 633
Madison, Wisconsin 5370

Dear Mr. Rueden:

Based on the information exchange at our meeting of January, 1991, I recommend, for your consideration, the following course of action as it relates to the Space Science and Engineering Center Magnetic Tape Archive.

1. Unless other requirements dictate a system changeover, continue the use of the U-matic recording system on the basis that there probably will be a consumer demand in the broadcast video industry world wide for the next 5 to 8 years. The format and media that will emerge as the dominant interchange media for industry is not clear at this point in time. A clear recommendation of a technology migration path for the archive is not possible given the state of the video recording industry with respect to recording formats and emerging technology i.e. High Resolution Television.

2. Annually reassess the state of the mass storage industry by attending at least one conference on information technology. The basis for this recommendation is to access on a yearly basis the viability and cost of available technologies.

3. Rewind the media in archive at three to five year intervals.

4. Maintain the recorders and playback at the state of the art to ensure the availability replacement parts.

5. Monitor the wind tension of the recorder and playback units

6. Maintain the environmental conditions be maintained at:

   Temperature .....70 .....+/-5 degrees Fahrenheit
   Relative Humidity.....50%.....+/-5 %

Should you have any questions, please call me at (612) 736-8147.

Sincerely,

W. M. Mularie

William M. Mularie

Tel (612) 736-6183 Fax (612) 736-4430

C. Appendix C. Information sources

ARCHIVE MEDIA INFORMATION SOURCES

8mm tape Exabyte	Cybernetics, Jamie Solak, (804) 873-9000
VHS cassette *	Honeywell, Jerry Wade, (303) 773-4659
Sony U-matic (UW)	University of Wisconsin, J.T. Young, (608) 262-6314
D2 drive *	Honeywell, Jerry Wade, (303) 773-4659
digital instr. recorder	Ampex, Mark Arola, (415) 367-4603
Ampex DST	Ampex, Mark Arola, (415) 367-4603
dat/dds	Wangdat, Inc., Mike Johnson, (714) 753-8900
optical tape (CREO) *	Honeywell, Jerry Wade, (303) 773-4659
mag tape cartridge (3480)	Storage Technology, Ben Duhl, 1-800 -888-3695 ext 8193
mag tape reel (6250)	IBM
write once optical (12")	Sony
QIC tape	Core Int'l, (407) 997-6033
write once optical (14")	Kodak
write once optical (5.25")	Sony
rewritable optical	Sony
rewritable optical	Sony
cd-rom	Discovery Systems, Carol Bucher, (614) 766-3112