1995117713

N95- 24133

ASF Archive Issues: Current Status, Past History, and Questions for the Future

Crystal A. Goula and Carl Wales
Alaska SAR Facility
University of Alaska
P.O. Box 757320
Fairbanks, Alaska 99775-7320
email 1: crystal@dino.gi.alaska.edu
email 2: cwales@iias.images.alaska.edu
Phone: (907) 474-7926
Fax: (907) 474-5567

S25-82
43469
p. 12

Abstract:

The Alaska SAR Facility collects, processes, archives, and distributes data from synthetic aperture radar (SAR) satellites in support of scientific research. ASF has been in operation since 1991 and presently has an archive of over 100 terabytes of data. ASF is performing an analysis of its magnetic tape storage system to ensure long-term preservation of this archive. Future satellite missions have the possibility of doubling to tripling the amount of data that ASF acquires. ASF is examining the current data systems and the high volume storage, and exploring future concerns and solutions.

Introduction:

Synthetic Aperture Radar (SAR) is an imaging radar technique involving the use of an aircraft or satellite-borne antenna to obtain an artificial radar aperture effect by utilizing the forward motion of the vehicle. Using the movement of the aircraft or satellite, the antenna emulates a larger sized aperture antenna. The technique produces the results of a larger aperture antenna, and is especially important when size limitations would prevent using the physically larger antenna.

The Alaska SAR Facility (ASF) was established at the University of Alaska Fairbanks in 1986. Funded by NASA, ASF is dedicated to the collecting, archiving, processing and distribution of SAR data. The major data-handling systems in use today at ASF were developed by the Jet Propulsion Laboratory, and installed in Fairbanks in 1990. ASF first began collecting data from the European Space Agency's ERS-1 satellite in August of 1991. More satellites were scheduled for later dates. ASF receives SAR data in real-time and tape recorded transmissions from satellites, processes the data into other usable forms, archives and distributes the data, in accordance with NASA's international agreements. Because of these agreements, ASF must maintain the archive of raw data for ten to fifteen years after the end of the satellite's mission.

ASF can receive SAR data covering Alaska, eastern Siberia, the Arctic Ocean, the north Pacific, and northwestern Canada. ASF collects large volumes of raw SAR data and processes the data into images that scientific researchers use to study sea ice, oceanography, geology, glaciology and botany. The processed images add to the large data store at ASF. Data are archived at ASF for long term storage on high density magnetic tape.

Satellites:

ASF is currently collecting data from two satellites: ERS-1 (European Remote-Sensing Satellite-1) and JERS-1 (Japanese Earth Resources Satellite). Incoming data from ERS-1 and JERS-1 is approximately 1.2 terabytes per month, or over 14.4 terabytes per year.

SATELLITE MISSION INFORMATION

	ERS-1	JERS-1	ERS-2	RADARSAT	ADEOS
Launch Date	July 17, 1991	Feb. 11, 1992	Spring, 1995	Spring, 1995	Feb. 1996
Mission life	3 years	2 years	3 years	5.25 years	3 years
Number of Links*	2 **	2	2 **	2	3
Data rate (mbps)	105	60/60	105	105/85	60/60/6
Orbital Period	100.47 min	95.87 min	100.47 min	98.594 min	98.59 min
On-Board HDDRs	no	yes	no	yes	yes
Archive Data Beyond Mission	10 years	10 years	10 years	15 years	n/a

* X band only -- does not include S band.

** ASF only collects data from the high bit rate signal. ASF does not use the low bit rate signal.

The ERS-1 satellite is the European Space Agency's (ESA) first remote sensing satellite. ESA launched ERS-1 in July of 1991. ERS-1 transmits data at 105 megabits/sec (or approximately 13 megabytes/sec). ERS-1 data passes last up to fifteen minutes and ASF records multiple datatakes per day. The average number of data-collecting passes per day is nine, which yields 41 minutes per day of data. ASF collects approximately 32 gigabytes per day from ERS-1. The anticipated mission life of ERS-1 was three years. At present, ASF is still collecting data from ERS-1. ERS-1 will be decommissioned after ERS-2 is operational.

The JERS-1 satellite is one of the Japanese space agency's (NASDA) Earth Resources Satellite. JERS-1 was launched in February of 1992. The JERS-1 satellite has an on-board tape recorder and can transfer two streams of data simultaneously. The JERS-1 satellite also has two sensors on-board, one SAR and one optical. The optical data are recorded and sent on to NASDA for processing. The SAR data are archived at ASF and sent to NASDA. Data are transferred at 60 megabits/sec (or 7.5 megabytes/sec), regardless of whether the data are real-time or recorded. ASF collects on an average of four passes per day, which averages about 19 minutes per day. ASF collects approximately 8.5 gigabytes from JERS-1 daily. The anticipated prime mission life was two years, however, JERS-1 is in extended mission phase, which could last for seven more years.

The ASF Facility:

All the ASF components are important to the successful operation of the facility. Focusing on how the data get to the archive and how the data are retrieved narrows the number of departments down to those two directly involved in the physical archiving processes, which are the Receiving Ground Station (RGS) and the SAR Processing System (SPS).

Functional Diagram - ASF Today

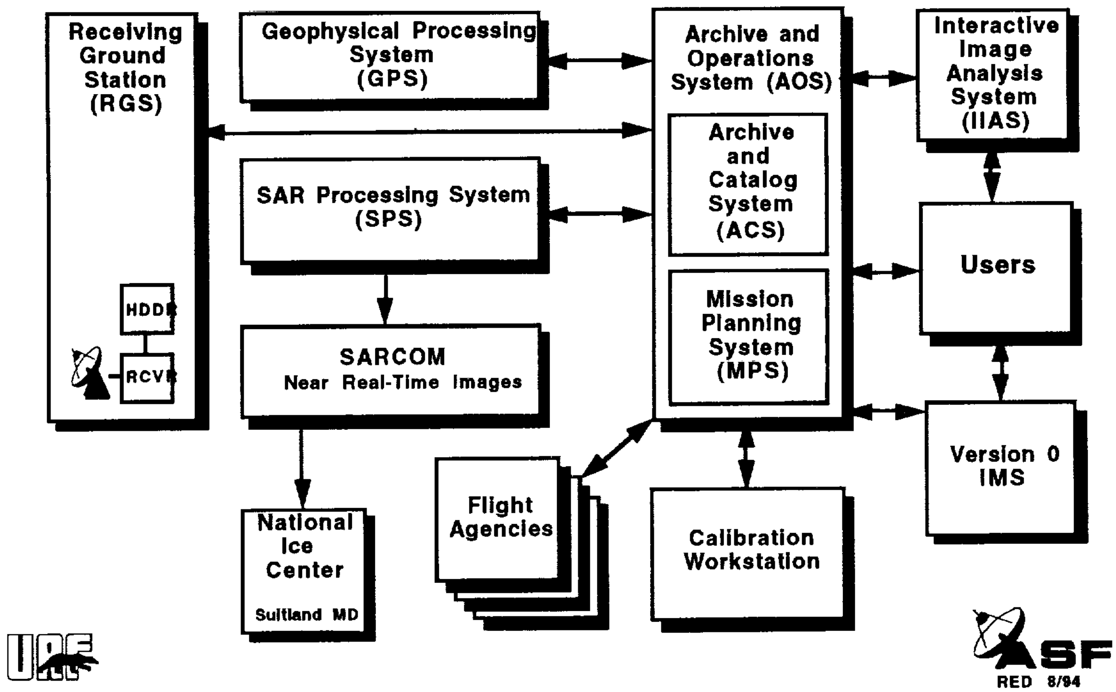

FIGURE 1 -- CURRENT ASF FUNCTIONAL DIAGRAM

Receiving Ground Station:

The RGS (Receiving Ground Station) tracks satellites with a 10 meter tracking antenna. Using high speed, high density recorders, the RGS then receives and stores the data from SAR satellites for later use by the processing system in support of researchers. The raw signal data recorded and stored during this process are considered level 0. ASF records two tape copies of the raw signal data. One tape is designated as the Archive Signal tape and put into storage as a backup to the second tape designated as the Working Signal tape. The Working Signal tape is used for data retrieval and processing operations.

Currently, ASF uses Honeywell HD96 and AMPEX DCRSi tape recorders to record incoming satellite data. In the case of the ERS-1 data, the DCRSi recorders record both the Archive Signal tape and Working Signal tape. With JERS-1 data, the situation is slightly different because of the on-board tape recorder. Data intended for NASDA are recorded on HD96 recorders, while SAR data to be used at ASF are recorded on AMPEX DCRSi tapes. For both the HD96 and DCRSi, data are recorded to the recorders in the serial mode.

The HD-96 reel tapes will hold about 15 minutes or approximately 12 gigabytes of raw signal data. The DCRSi tapes will hold 40 to 50 minutes or 47 gigabytes of raw signal data.

SAR Processing System:

The SAR Processing System (SPS) reads and decodes the raw data into image products. Data that have been processed by the SAR processor are considered level 1 data.

The only tape recorders connected to the SPS are the AMPEX DCRSi recorders. The data are accessed in parallel mode. ASF cannot retrieve data from the HD96 tapes unless the data were recorded or copied on to DCRSi tapes.

Raw data can be processed into full resolution images and low resolution images. It takes 195 megabytes of raw data (approximately 15 seconds of data transfer) to make one ERS-1 full or one low resolution image. The ERS-1 full resolution image is 8k x 8k pixels and covers an approximate area of 100 km x 100 km. JERS-1 raw data size is slightly smaller. The full resolution image is slightly smaller also, covering an approximate area of 100 km x 75 km. Processing the raw data into a full resolution image generates a file approximately 64 megabytes in size. By taking an 8 x 8 average of the full resolution image, the full resolution image can be processed into a 1k x 1k pixel low resolution image that takes up approximately one megabyte file space. To date, ASF has processed over 100,000 full resolution images.

It takes on the average 20 minutes to process one minute of raw data. With a datatake lasting anywhere from six to fifteen minutes, the processing of one datatake can run 120 to 300 minutes. One DCRSi tape can hold ten to twelve passes. The access time from end to end of an AMPEX DCRSi tape is five minutes. To process one DCRSi tape would take over twenty hours.

Archive:

ASF is collecting approximately 1.2 terabytes per month. ASF's archive consists of DCRSi tapes only. Currently, there are 980 Archive signal tapes and 1162 Working signal tapes on compact shelves at ASF. ASF also stored full resolution images on DCRSi tape. There are 237 of these image tapes in the archive. ASF currently has approximately 96 terabytes in the archive on Archive and Working Signal tapes. With another approximate 10 terabytes of full resolution images, ASF's current data storage totals 106 terabytes.

Along with the DCRSi main archive, ASF also has low resolution images archived on 12" optical platters in a jukebox. Currently, ASF has over 146,000 low resolution images stored on the optical platters, totaling about 146 gigabytes.

Use of AMPEX DCRSi Recorders at ASF:

ASF presently has six AMPEX DCRSi recorders on site. Three of the recorders are dedicated to the RGS and three are dedicated to the SPS. A recorder can be switched between subsystems, if needed to keep ASF operational. Two of the recorders were delivered to ASF in January of 1989. Three other recorders were delivered around November of 1990. The sixth recorder arrived in May of 1992. The sixth recorder is slightly different from the other five recorders. AMPEX had made some design modifications on the recorders by 1992. One of the new features on the sixth recorder is a low tension tape transport. This feature lowers the tension on the tape in the recorder and reduces the amount of stretching and fatigue on the DCRSi tape. Another one of the new features is a wide tip scanner. This feature improves the ability of the recorder to read from and write to the tape. The sixth recorder is currently installed on the RGS.

Figure 2 shows a simplified layout of how data are recorded on the DCRSi tapes. Two tracks are recorded longitudinal. The control track is used by the AMPEX recorder, and ASF does not do anything with this data. The user log and coarse address track is used by the AMPEX recorder when searching for data to get the tape roughly to a requested address. The user log contains information such as satellite identification, type of data, and the satellite revolution number. The recorder uses the coarse address information to get the tape near the specific address. The recorder will then read the transverse data to locate the specific address. The RGS computer will record the beginning and ending scan addresses from the DCRSi, so that the data can be retrieved later using the SPS. An example of a coarse address is 100100, while an example of a scan address is 100112. The DCRSi recorder has a bit error rate (BER) of 1×10^{-7} or better. DCRSi tapes are rated for 500 passes in low tension tape recorders, and 200 passes for high tension tape recorders.

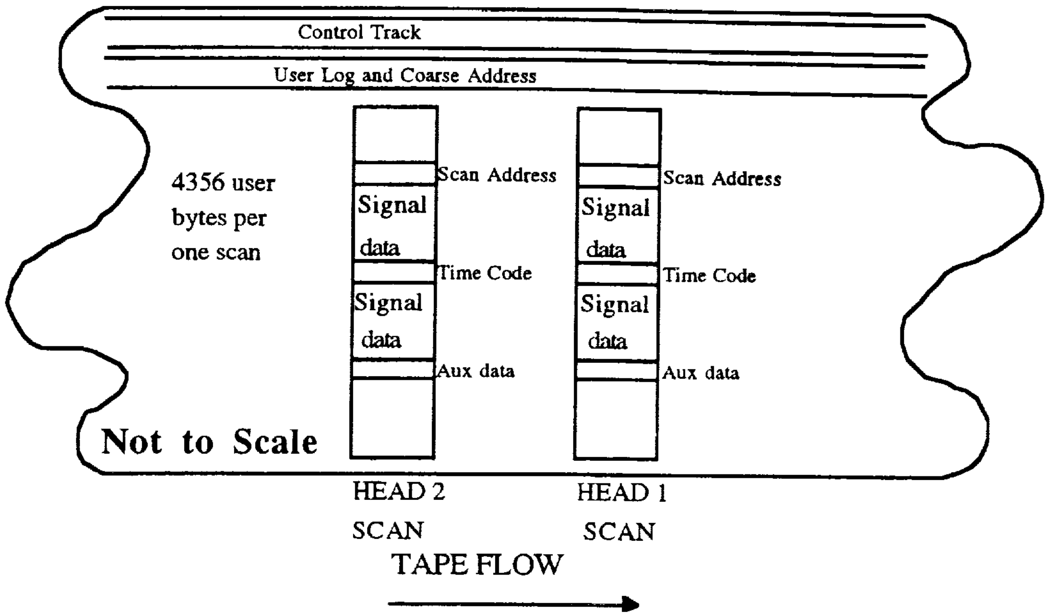

Figure 2 -- Simplified Data Scan

Figure 3 shows a simplified diagram of the scanner head and tape assembly. The data are written on the DCRSi tape from the scanner while both scanner and tape are moving. Although the tape is moving, the tracks of data are written in transverse mode. The scanner is moving fast enough that the tracks are only .1 slanted from the horizontal, and so is considered transverse. The scanner is rotating at a speed of 512 rps. The linear tape speed is 5.28 ips. There are six heads on the scanner. Each head will scan a track of 4374 bytes of data onto the tape, consisting of 4356 bytes of user data and 18 bytes of addressing/time code data. As each head will write one track of data per revolution, the recorder writes approximately 3073 tracks per second, with an average of 582 tracks per inch of tape.

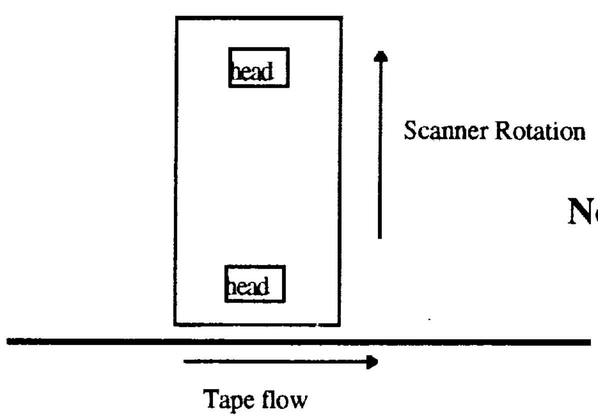

Figure 3 -- Simplified AMPEX Head/Scanner Assembly

ASF invests considerable effort to support this suite of recorders. ASF has two staff members, trained by AMPEX, to perform standard maintenance and repairs on the DCRSi recorders. Every attempt is made to standardize all measurements on the recorders. ASF performs weekly maintenance on the DCRSi recorders, including a crossplay test. Using a single tape, a crossplay test pattern is recorded on each recorder. The tape is then tested on each recorder. A computer records the differences and errors in each of the test patterns. This process shows the staff which machines require any type of head phase adjustment. The standard crossplay testing is done in the serial mode.

ASF maintains a supply of spare parts and boards on site. There is a backup tape transport assembly for on site replacement. If the recorder cannot be repaired because ASF's spare is in use by another recorder, ASF must contact AMPEX to see if AMPEX has a spare part in their supply. If AMPEX does, they will ship the part to ASF. ASF will replace the part and send the damaged part back to AMPEX. ASF usually gets the working part in a couple of days, so down time is minimal. If AMPEX does not have a spare part in their supply, ASF's part must be sent to AMPEX for repair, which can take at least a month, but typically more like two to three months. Of the six AMPEX DCRSi recorders on site, on the average five recorders are functioning at any given time.

Since 1991, ASF has accumulated over 106 terabytes of data and has supported the processing of over 100,000 image products for science and operations users nationally and internationally. ASF is investigating several operational issues regarding the combination of tape recording systems and data-handling systems, which may be helpful to other users.

Retrieval of Signal Data:

ASF is experiencing problems retrieving raw signal data from the AMPEX DCRSi tapes after only three years of data collection. When recording satellite data, any number of reasons during transmission could cause a data dropout on the tape. Generally, an operator watches the RGS equipment during a download of data. In particular, the operator is watching a spectrum analyzer to make sure a good X-band signal is being received. If the X-band signal drops during recording, this is considered a data dropout, and is hand-noted in the RGS log for reference later. The signal loss indicates that there could be more than one segment of data to process. If there is a problem during processing, the RGS log is consulted to determine if an operator noted a problem during the satellite datatake. Under normal operations, the processor reads a Working Signal tape, finds a code indicating the beginning of a datatake, and accesses the data until a code indicating the end of the datatake is found.

When the SPS tries to read the signal data, and reports back more than one or two segments of data, the RGS log is checked to see if there was a problem when the data was recorded. If not, then there is a problem with retrieving the signal data. A processing data gap occurs when the SPS loses synchronization with the scan address codes in the raw signal datatake, meaning that the next scan address is not what the SPS was expecting. The SPS assumes that this is the end of the segment and searches for an ending code. Finding none, the SPS will then search for a new beginning code. Since this problem is occurring in the middle of a data segment, the SPS will find neither codes. The SPS will then assume that that was the end of the data, and begin processing the next section of the data segment that the SPS can read, using the same beginning code. An operator will manually cancel the request to retrieve this datatake with the number of segments goes above six. Figure 4 shows what happens when the SPS loses sync with the data on the tape. Approximately 5% of the datatakes processed to date have shown problems during retrieval. There was no indication of physical damage to the tape, nor does any data suggest that ASF has accessed this tape more than 200 times.

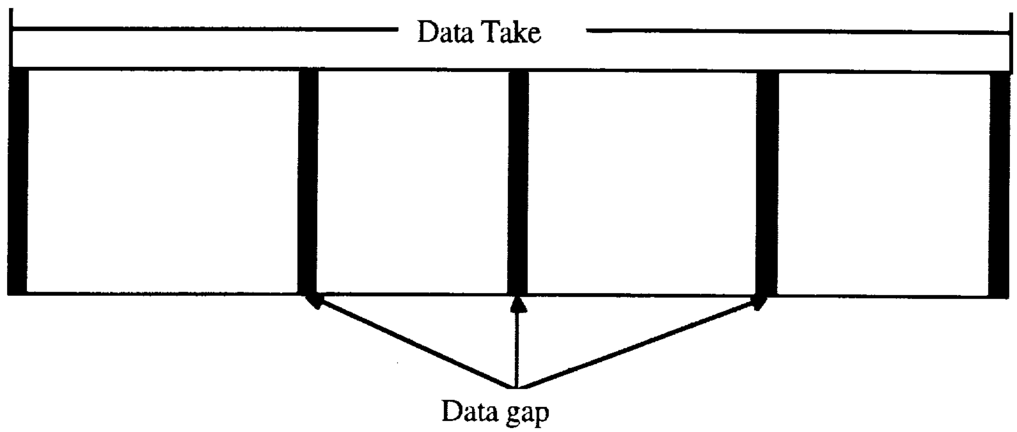

Figure 4 -- Data gaps on a single segment datatake

Normally ERS and JERS data will have no more than three planned segments per datatake, with the typical number of segments being one or two. The sync loss problem can turn a one or two segment datatake into a twelve segment datatake. A data gap is where the SPS loses sync with the scan addresses. There are two ways of trying to recover the data in the data gaps. One method involves moving the tape to another recorder and trying to access the data there. Different tape machines will read the same tape differently. There is no guarantee that changing drives will solve the problem, and switching drives to reprocess the data is a time consuming operation. At one point, ASF scanned the Archive Signal tape first to see if errors would come up in the same spot on the Archive signal tape as the Working Signal tape. If a scan of the Archive Signal tape experiences the same errors in the same spots, ASF assumes that a dropout in data did occur during the original recording of the raw signal data. The most expedient and most successful method of fixing the problem is to dub that datatake from the Archive Signal tape to another tape. Because the process of dubbing the Archive Signal tape to another tape was so successful, ASF has eliminated the scanning step. To date, ASF has dubbed approximately 225 datatakes. These dubs have added an additional 22 DCRSi tapes to the archive. By using one or both of these solutions, ASF resolves the data problem about 95% of the time. ASF has been unable to retrieve less than .3% of the archived raw signal data.

After consulting with AMPEX about the symptoms, the problem was diagnosed as a head phase and channel gain/equalization problem. This problem is the result of crossplay: recording the tape on one machine and trying to play the same tape on another recorder. One of the factors that affect the playback of a recorder is channel gain and equalization. The channel gain and equalization settings affect the reading of the data. The channel gain refers to the amplitude of the data signal. The channel equalization minimizes the errors in a data signal. By adjusting these settings, the number of bit errors can be reduced. Adjusting the channel gain and equalization settings is a way of optimizing the recorder's performance, but it is a time-consuming process. Another part of the problem with crossplay is head phase. The head phase on one machine is going to be slightly different from the head phase of another machine. This means that the timing control for a specific head will turn the head on either before the head has reached the tape data or while the head is in the middle of the tape data. Trying to read the tape when the head is not where it should be results in the dropout-like error. The head phase and channel gain/equalization are set when a scanner or transport assembly is replaced. It is not part of the weekly maintenance to check these settings. If ASF experiences multiple data retrieval problems with a recorder, ASF will check the gain/equalization and adjust if necessary.

AMPEX informed ASF that the new AMPEX DCRSi 107 should solve this problem. The new AMPEX 107 auto adjusts play alignment to the tape. Playback alignment may improve a high bit error rate.[6] ASF is in the process of acquiring a 107 model from AMPEX to verify if this would indeed solve the problem. The play alignment feature makes internal adjustments to the following: gain, equalization, clock phase, and tracking. The playback command is issued to the 107, but the adjusted settings are not permanent. If the save command is not issued, a reset or power off will clear these settings out of the memory and return the recorder to the original operating range.

Retrieval of Image Data:

ASF also archived the full resolution images output by the SAR processor. ASF was having problems completing approximately 14% of the full resolution image requests. The SPS would encounter problems when retrieving image data from an Image Archive tape. This problem was almost exclusively an addressing problem. There are two variations of the full resolution images addressing problem.

The JPL designed system software treats the tape drive as a disk drive, by preaddressing the tape. The preaddressing of a tape simply involved writing sequential addresses on the DCRSi tape. After an image was recorded on the DCRSi tape, there was the chance that the DCRSi would not write over the preaddressed address, causing a discontinuity between the legitimate addresses of the images. When trying to retrieve the images, the recorder would read one of the preaddressed addresses, which was not contiguous with the addresses for the images. The software was not designed to handle this problem, and after a few tries to retrieve the data, the process would stop. The result was that an image could not be retrieved because the correct address could not be found.

The second part of the addressing problem involved potentially corrupt scan addresses. AMPEX told ASF that there was a possibility that the scan address in the transverse data could be corrupted. If the scan address was corrupted, the software would not be able to find the exact address where it should be and the image retrieval process would be stopped. This problem had the same results: the image could not be retrieved because the correct address could not be found.

An additional problem with retrieving the image data was the bit error rate (BER). For raw data the acceptable BER is $3x10^{-5}$. For the full image data the acceptable BER is $1x10^{-9}$. The rated BER of the DCRSi is $1x10^{-7}$ or better. The two orders of magnitude between the raw data and rated BER allows a margin for error in the data. Because the full image demanded a much lower BER, the recorders would have to operate above the rated BER all the time, which is not a reasonable expectation. Even without the preaddressing problem, ASF believes that the full image data would have been more difficult to retrieve because of the low tolerance for errors in the data.

Originally ASF attempted to solve the addressing problem. Changes were made in the software to bypass the preaddressing issue, but the secondary corrupt scan address problem persisted. A fix to the corrupt scan address problem was discussed. It would have been possible to modify the software to allow an operator to back the tape up to a readable address, and then skip forward the expected number of bytes between this readable address and the requested address, however this fix would not have solved the BER issue. Because of these problems and other constraints, ASF abandoned the archive in August 1994. ASF decided that it would be more efficient and more successful to process an image when a user requested it, rather than archive the image, use up limited archive space, and try to retrieve the data when and if a user requested the image. ASF is changing to a process-on-demand strategy, where signal data will be processed to image data, delivered to the user and no longer archived. This change is being made for several reasons, including budget constraints, space limitations, and evolution of the entire data system. While this change in strategy "solved" the problems with the full resolution image archive, it may introduce additional problems in the length of the archive life by increasing the frequency of access to signal data.

Archive life:

The estimated shelf life of the AMPEX DCRSi tapes is at least fifteen years.[1,7] During shelf life, degradation of the magnetic coating will eventually lead to unreadable tapes. To date, no deterioration of the archive as a function of age has been detected. Reading an archive tape will also cause degradation of the magnetic coating. As the DCRSi tapes are rated for 500 passes in low tension machines and 200 passes in high tension machines before suffering loss of data, increased access to the archive tapes will hasten their decline. This is especially true since all but one of ASF's recorders are high tension machines. ASF is migrating to a process-on-demand strategy where each time an image is requested by a user, the Working Signal tape will be accessed to process the image and satisfy the request. This will put increased wear on the tapes, which could shorten their lives. In turn, the increased wear on the Working Signal tape would also increase the frequency of duplicating from the Archive Signal tape. Also, for long term storage, tapes should be rewound every one to five years to relieve stresses in the pack.[1] Every access to Archive Signal tape increases the risk of damage.

Because of the high speed access of the DCRSi recorders, catastrophic damage to the tapes could result in loss of all data on the tape. Catastrophic damage includes broken tape, tape stretch, or severe crinkle in tape that could catch as the tape passes the scanner. Even the act of dropping a tape cartridge could damage the data on the tape.[1] Minor damage, such as minimal tape edge crinkle, could result in the loss of the information where the damage is, but the rest of the tape should be readable. This makes the archive "fragile" in the respect that any physical damage to the Archive Signal tape could result in loss of irreplaceable data. Because the Archive and Working Signal tapes are stored in the same room, any damage to the current storage area, such as fire or water leakage, could lead to loss of data as well.

Future Focus:

The other satellites in the Satellite Mission Information chart are future data sources. The addition of ERS-2 and RADARSAT in 1995 will at least double, if not triple, the data volume ASF is currently handling. Because RADARSAT also carries an on-board recorder like JERS-1, multiple data streams could also be possible, which would also affect the incoming data volume. With the new satellites, incoming data will increase from approximately 1.2 terabytes per month to between 2.3 to 3.3 terabytes per month.

Along with the new satellites, ASF will be archiving and processing data collected at the McMurdo station in Antarctica. ASF anticipates that McMurdo will send approximately 800 DCRSi tapes every six months. This equals approximately 36 terabytes per shipment. Because these tapes are ASF's only copies, ASF will have duplicate the tapes when they arrive to produce a Working Signal tape. The originals from McMurdo would become ASF's Archive Signal tape.

Soon ASF will add two Sony ID1 recorders to the RGS. In approximately one year, ASF will add six more ID1 recorders and a second 11 meter tracking antenna to the RGS. The six ID1 recorders will be part of the ADEOS satellite recording process. The two Sony ID1 recorders will replace the DCRSi recorders for ERS-1 SAR data collection. The ID1 recorders will record both the Archive Signal and Working Signal tapes. There is no present plan to convert the existing DCRSi Archive and Working Signal tapes to ID1 tapes. The ID1 uses a DD-1 medium tape, which holds about 40 minutes of raw signal data, approximately 41.2 gigabytes and has an end to end access time of less than 90 seconds.

For long term planning, ASF is considering the following factors: large volumes of data, long term archive responsibility, high download data rate, ease of operation, maintenance, and the access and retrieval necessary to support production and distribution of data.

Solid state memory and disks have faster access times than tape, however, they are generally not economically feasible. Although research is making progress in the high capacity disk storage to reduce costs, beyond a certain point disk storage is still not economically sound. Tape, either magnetic or optical, are still the most likely storage methods for ASF.

Optical tapes tend to have a higher storage capacity than magnetic. Both tapes have similar access speeds. Improvements in magnetic tapes have made some tapes capable of lasting more than twenty years, but the standard for magnetic tapes still seems to be ten to fourteen years. Durability during data reads is another factor to consider. Optical tapes seem to be more durable. Tests on the ICI 1012 optical tape reel, have shown that the tape can withstand 250,000 passes with no degradation of data, while magnetic tapes are typically 2,000 to 40,000 passes.[2,3] The optical tape systems have slower write speeds than magnetic tape systems. Existing laser and media technologies achieve a write speed of approximately 3 megabytes/second (24 megabits/second).

Robotic silos would reduce labor costs of some of ASF's archive and data retrieval process. The AMPEX DCRSi recorders cannot be used in a robotic silo. Robotic silos have a range of capabilities to assist in archive and retrieval of data. The drives for receiving and play back of satellite data could be attached to the same silo, however for better archive protection, two separate silos, one for Working Signal tapes and one for Archive Signal Tapes, will be investigated. The tapes could be passed between silos, and used on different drives, so that if all the recorders in one silo are occupied, the data tape can be passed to another silo with an available recorder. The access time in a silo involves accessing and mounting the tape. In some cases, manufactures also include drive preparation time. Access times range from four to eighteen seconds. The number of tapes that a silo can store varies with manufacture. Some silos can hold 6000 tapes (such as StorageTek Powderhorn), while others hold only 200 tapes. The type of tapes used in silos varies as well, from VHS to IBM 3480.

For future data storage improvements, ASF will be looking at archival aspects, such as media life and durability, volume of media, and robotic possibilities. Other factors such as write speed and cost of the equipment to purchase, maintain, and operate will also be important.

Summary:

As the volume of data at ASF continues to grow, the current data handling systems at ASF will be stretched to the maximum. With the data volume more than doubling in the next few years, ASF is examining the current data handling systems. From operational experience, ASF has a new understanding of the AMPEX DCRSi recorders and how they function in the current data handling systems. This understanding has led to some operational and program changes at ASF, but these changes may not be enough to accommodate future data handling and storage requirements. Increases in data volume and frequency of data access will affect ASF's data handling and storage systems. Machine cost, machine capabilities, media life expectancy and durability, archive safety, and robotic capabilities are some of the factors that ASF will consider when planning equipment improvements to the data storage and handling system. With careful planning, ASF will insure the protection of the irreplaceable data collection for future scientific research.

References:

1. John Berbert, Ben Kobler, P.C. Hariharan, Jean-Jacques Bedet, and Alan M. Dwyer, "Magnetic Media", Greenbelt, MD, August 1993.

2. John M. Howard and Mark Hewish, "Data, Data, Everywhere: Competing Approaches to Mass Storage", International Defense Review, vol. 25, no.6, PP 75-79, June 1, 1992.

3. Storage Technology Contingency Plan for the ECS Project, EOSDIS Core System Project, August 1993.

4. David Cuddy, Eugene Chu and Tim Bicknell, "Alaska SAR Facility Mass Storage, Current System", Third NASA Goddard Conference on Mass Storage Systems and Technologies, Benjamin Kobler and P.C. Hariharan, eds., College Park, MD, October 1993.

5. Gunter Weller and W.F. Weeks, "The Alaska SAR Facility: An Update", Arctic Research of the United States, vol. 2, no.1, PP 27-31, Spring, 1988.

6. DCRSi 107 lab instruction manual, AMPEX Corporation, B5-B10, 1994.

7. DCRSi Media Archival Properties, AMPEX Corporation, 1994.

8. AMPEX DCRSi 2471/2473 Specification Summary, AMPEX Corporation, 1994.

Acknowledgments:

We would like to acknowledge Ron Faust, Thom Reimers, Brett Delana, and Tom George for their time and generous assistance with this paper.