

Accessing Chapter 10 Recorder Media

From Windows PCs

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ABSTRACT

The RCC IRIG Chapter 10 standard requires that Chapter 10 recorders use the STANAG-4575 (NATO Advanced Data Storage Interface) file system to store data files. The STANAG-4575 standard defines a linear file system in which each file is stored in a single contiguous block of disk space. There is a small directory listing at the beginning of the disk. This listing stores the starting position and length for each file. It also stores the file's name and its creation date and time. This file system is very efficient for storing files that are recorded sequentially because it does not require the disk to constantly update a file allocation table on each write.

Unfortunately, the STANAG-4575 file system is not directly supported by Microsoft Windows. This means that it is not possible to simply attach a recorder's disk to a PC and copy the files directly using Windows Explorer. This paper will discuss an approach that allows the contents of a STANAG formatted disk to be read from a standard Windows PC. In addition to copying files from the disk, this approach allows several other useful operations to be performed on the disk. These operations include advanced copy options such as partial file copies and splitting files into multiple pieces. It can also provide a mechanism for deleting files, reformatting the disk and performing a sanitization procedure on a disk to declassify it.

KEYWORDS

Chapter 10, STANAG-4575, Data Recorders

INTRODUCTION

Flight test data recorders have several unique requirements that standard PC file systems are not optimized for. The file system on a data recorder must be capable of continuously writing files at a high speed. It also needs to have relatively low overhead and it must be tolerant of sudden power losses. The STANAG-4575 file system is ideally suited for use with flight test data recorders. This file system is designed to make it simple and easy to write a series of files to a disk in a linear fashion. For these reasons, the STANAG-4575 file system must be used on RCC IRIG compliant Chapter 10 data recorders.

While the STANAG-4575 file system is ideal for use in flight test data recorders, it is not a widely known standard outside of the telemetry community. Thus it is not supported by common PC operating systems like Microsoft Windows and Linux. This causes a problem after a test flight because the flight test engineers need to copy the data files from the recorder to a standard PC so that the data can be analyzed. The data must be copied relatively quickly so that the removable memory cartridges can be reused on a subsequent test flight. Typically the memory cartridges will also need to be reformatted before the next test flight. Depending on the security level of the flight test program, it may also be necessary to perform a sanitization procedure on the disk before it can be reused.

CHAPTER 10 BACKGROUND

One of the principle goals of the RCC IRIG Chapter 10 standard is to define a mechanism for recording different types of data from multiple sources in a single recording. The standard defines a file format that achieves this goal. Chapter 10 files are comprised of data packets. Each packet stores data from a particular source in a data type specific format. Each packet contains a header and a body. The packet header identifies the data source and its type. The body of the packet contains actual flight test data that is collected from the source.

The Chapter 10 format has several well defined features that are designed to ensure that data is promptly written to disk. In particular, no packet can contain data that was collected more than 100 ms ago. This guarantees that data is committed to the disk promptly. The standard also defines a special time packet format. Time packets must be written to the file every second in order to provide an easy time reference.

In addition, Chapter 10 files must start with a computer generated data packet that contains an RCC IRIG Chapter 9 Telemetry Attributes Transfer Standard (TMATS) entry. The TMATS entry describes all of the data sources that are recorded in the file. This makes it possible for each Chapter 10 file to be self-describing. The main advantage of this is that there is no need to store the original telemetry system vendor's setup with the data. If the data needs to be viewed in the future all that will be needed is data playback software that understands Chapter 10 data and Chapter 9 setup packets.

STANAG-4575 BACKGROUND

The STANAG-4575 file system is a NATO standard for data storage on removable memory modules. The RCC IRIG Chapter 10 standard uses a subset of the STANAG-4575 file system. This file system was selected because it is optimized for rapidly writing sequential data to a disk. The other advantage of selecting a standardized file system for Chapter 10 is that it guarantees both forward and backwards compatibility for Chapter 10 disks for the lifetime of the standard. In addition, the STANAG-4575 file system has very low overhead and supports extremely large files. These two properties are crucial for flight test data recorders which can create recordings that contain over 100 GB of data on a single test flight.

A STANAG-4575 formatted disk contains two main sections. The first section contains a series of directory blocks that describe the files that are written on the disk. The second section contains the actual file data. Each block is typically one sector on the underlying media. Each directory block contains a header that consists of the following items:

- Magic Number
- Version Number
- Shutdown Byte
- Number of File Entries in the Block
- Volume Name
- Forward Link
- Reverse Link
- Entries For Several Files

The magic number is the ASCII string “FORTYtwo”. The revision number records the version of the RCC IRIG 106 standard. The shutdown byte indicates whether or not the disk was powered down safely. If the shutdown byte indicates an error then the file entries may not be correct. The next item in the header is the number of file entries that follow. For a typical 512 byte sector, there will be four file entries. The forward and reverse links tell the system the block number of the next and previous directory block. This would theoretically allow for the directory blocks to be scattered across the disk. In practice all of the blocks are written consecutively at the start of the disk.

Each file entry describes a file that resides on the disk. The file entries are 112 bytes long. A file entry includes the following items:

- File Name
- Starting Block Number
- Block Count
- Actual File Size in Bytes
- File Create Date and Time
- File Close Time
- Time Source Byte

Since files are written to disk sequentially, all that a user needs to know about a file in order to read it is its starting block number and its actual size in bytes.

ACCESSING STANAG-4575 FORMATTED DISKS FROM WINDOWS

One of the problems that end-users have with STANAG-4575 disks is the need to access them from standard PC Operating Systems like Microsoft Windows. There are two main solutions to this problem. One solution is for the hardware on the Chapter 10 recorder to provide a mechanism that exposes the contents of the STANAG formatted disk to

Windows in a standard way. For example, a Chapter 10 recorder could provide an Ethernet connection and allow the user to login to the disk via FTP.

The other solution is to use a software application that runs on a standard PC to read the contents of the removable disk drive over a standard interface like 1394 Firewire, USB or Fibre Channel. The user will only need to provide power and data connections to the removable drive. The software solution will allow a user of any version of Windows from Windows 2000 to Window 7 to access the disk. The remainder of this paper will discuss the software based method that TTC has developed for accessing STANAG-4575 formatted disks from Microsoft Windows without any special ground hardware.

MEDIA MANAGER SOFTWARE

TTC has solved the problem of accessing a STANAG-4575 formatted disk by creating a Windows application that bypasses the Windows file system drivers and reads directly from the disk. This application is called the Media Manager. It understands the STANAG-4575 file system so it is able to read and interpret the directory blocks on the disk. This allows the application to provide all of the standard file manipulation functions that users need to perform on a disk.

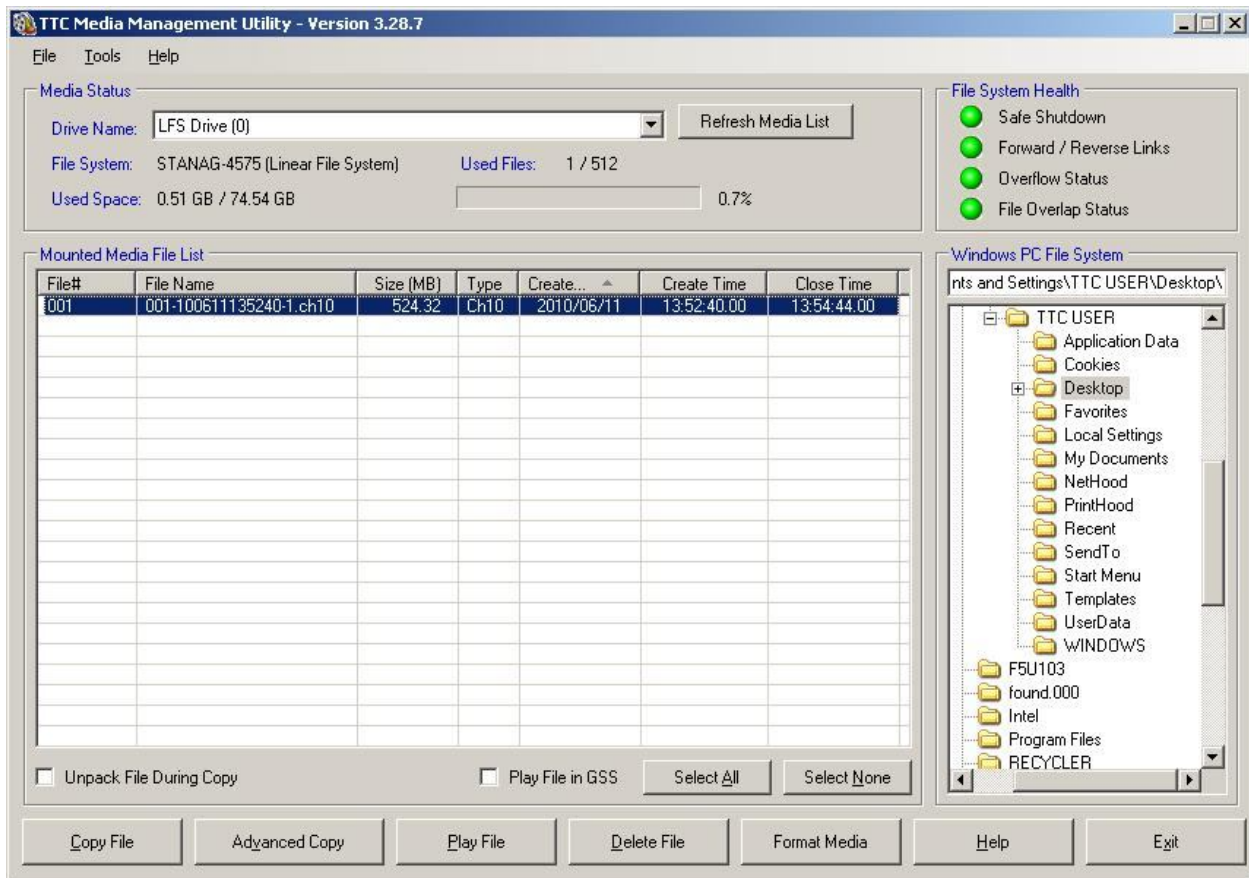


Figure 1: Viewing a STANAG-4575 Disk in the Media Manager Application

When the Media Manager is started, it scans all of the storage devices that Windows detects in the PC. If it determines that a storage device is formatted with STANAG-4575 then it adds it to the list of drives that Media Manager can access. When the user selects one of the STANAG-4575 formatted disks, the Media Manager will then read the directory blocks from the selected STANAG-4575 disk and display a file listing similar to the way that Windows Explorer displays files on a standard hard drive.

To interpret the directory listing on a STANAG-4575 disk, the Media Manager starts by reading the first directory block. It then follows the forward links in each directory block until it reaches the last directory block. On a typical STANAG-4575 disk, there will be 128 directory blocks. Since each 512 byte block can contain four files, this means that a maximum of 512 files can be stored on the STANAG-4575 disk.

As the Media Manager is reading the directory blocks, it looks at each file entry. A file entry can either be empty or it can contain a file. If a file entry contains an actual file then the Media Manager will read the file name, the file start block, the file size and the start and end time stamps for the file. This allows the application to display a list of the files for the user. The user can then select the files that they want to manipulate. The starting block number and the number of blocks used by the file are not displayed to the user. Instead the user is simply shown the total size of the file in megabytes.

One possible issue that complicates reading the directory structure from STANAG-4575 disks is endianness. The directory block's structure is defined by the IRIG-106-09 standard to be "Big Endian". This means that the most-significant bit of each number in the directory entry comes first. However, some early Chapter 10 recorders used "Little Endian" directory blocks where the least-significant bit of each number came first. An easy way to detect this issue is to look at the reverse link in the first directory block. The reverse link in the first block must point to the first block. If the reverse link appears to be in "Little Endian" format then the Media Manager can compensate by reversing the bits in all of the numbers in the directory entry.

The most common operation that users need to perform on a STANAG-4575 disk is to copy the files from the disk onto their PC's hard drive or a network drive. The Media Manager allows the user to select one or more files and copy them from the STANAG-4575 disk to the PC. The copy process works by locating the first block on the disk that belongs to a file and then copying all of the data from the file. Due to the design of the STANAG-4575 file system this is very simple because the file is guaranteed to be stored in contiguous blocks on the disk.

The Media Manager also supports several advanced copy operations. These operations allow files to be manipulated as they are copied off of the recorder drive. One option is the ability to split files into multiple pieces. This allows very large files to be broken up into multiple smaller pieces for storage or easy data exchange purposes. Another option is the ability to copy part of a file. This is done by specifying a starting position and a length for the copy operation. These advanced options increase the flexibility of the file

copy process and allow the user to perform some simple reprocessing of the data while copying it from a recorder memory cartridge to a PC.

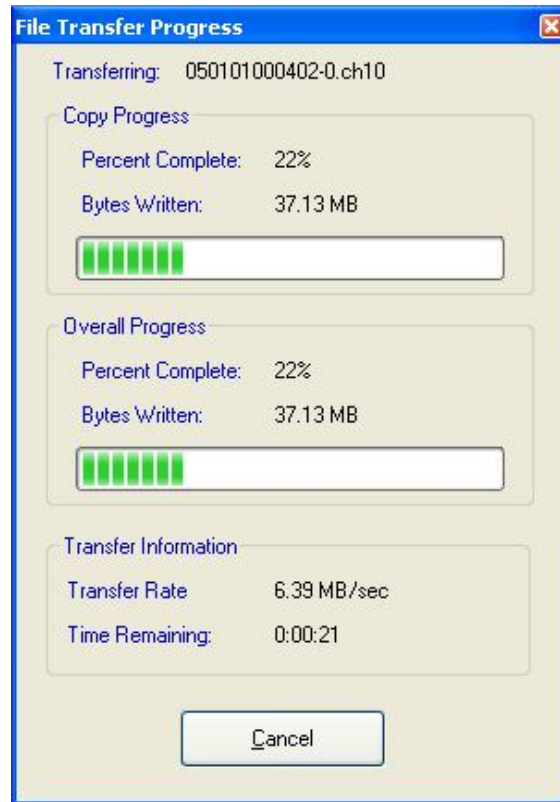


Figure 2: Copying Files

Another feature of the Media Manager is the ability to delete files from a STANAG-4575 disk. The STANAG-4575 file system does not support file deletion in the same manner as most file systems. When a file is deleted from a STANAG-4575 disk, the file entry in the directory block is cleared. This is similar to the way that most file systems delete files. The unusual aspect of file deletion is that the data blocks that are allocated to the file are not freed when a file is deleted. The reason for this limitation is the fact that each file on the STANAG-4575 disk is recorded as a single contiguous block of data. STANAG-4575 does not support fragmented files like most other file systems. Thus the only place that new files can be recorded is at the end of the disk after all of the existing files. This means that the only way to free space by deleting files is to delete the last (most recently recorded) file on the disk.

In order to recover disk space after deleting a file, the disk needs to be defragmented. The defragmentation process involves two steps. In the first step the directory blocks are rewritten so that all of the files are in consecutive file entries. The second step is more time consuming. It involved moving the files on the disk so that they are contiguous and there is no wasted space between files. In some cases, this can require rewriting all of the files on the disk. For example, this would happen if the user deleted the first file on the disk but kept all of the other files.

After the recorded flight test data is copied from a STANAG-4575 drive to a PC, the drive must be prepared for reuse. At minimum, the drive should be reformatted with an empty STANAG-4575 directory structure. The Media Manager provides two formatting options. The first option is a quick format that simply rewrites the 128 blocks that comprise the directory structure. This is an extremely quick operation. The second option is a full format. The full format involves rewriting the directory structure and then zeroing out the entire contents of the disk. This allows the user to start with a clean disk and guarantees that no old data will get mixed in with the new data from the next test flight. However, the full format process does not qualify as a declassification procedure because the drive is only written once.



Figure 3: Performing a Full Format

For recorder disk drives that support a declassification or sanitization feature, the media manager has the ability to invoke this procedure. A declassification procedure involves running a multi-step process where various data patterns are repeatedly written to and erased from the disk. The goal of the declassification procedure is to completely destroy any remnants of the original data that was recorded on the disk. In order to do this properly, the drive manufacturer must provide a procedure built-in to the drive's firmware that performs the actual process. During a declassification procedure, the media manager monitors the progress of the operation. When the procedure finishes, the disk drive must be reformatted with STANAG-4575 so that it can be reused.

The Chapter 10 standard also provides a unique method of programming a Chapter 10 recorder by placing a specially named Chapter 9 TMATS file on an otherwise empty removable disk drive. If a removable disk drive with a TMATS file is inserted into a Chapter 10 recorder then the recorder will configure itself from the TMATS file on power-up. The Media Manager has the ability to copy a TMATS file from a user's PC to a recorder disk drive. This provides an easy way for users to program their Chapter 10 recorders.

FUTURE WORK

There are several additional features that could be added to the Media Manager to help users work with STANAG-4575 disks that contain Chapter 10 data files. One of the most useful features would be a data recovery option. This feature would make it possible to restore the directory structure on a STANAG-4575 disk in the event that the directory structure was damaged or lost. The most common cause of an error in the STANAG-4575 directory structure is a sudden, unexpected power failure. If the power fails while the disk is writing to the directory blocks then there is a possibility that the directory will be damaged. The reason for this is that solid state flash memory writes data by first erasing the current data and then writing the new data. If power fails in the middle of this operation then the old and new contents of the data block can be lost.

The data recovery feature could take advantage of the structure of Chapter 10 data files to easily determine the boundaries of each file. Since every Chapter 10 file begins with a TMATS record and each file starts at the beginning of a disk block, it is relatively easy to determine the starting blocks for each file on the disk. If all of the files are contiguous and none of them have been deleted then all of the files except for the last file can be restored simply by locating all of the TMATS packets on the disk. The starting position for the last file on the disk can be easily detected but it is harder to determine where the file ends. In order to determine the end of the last file, all of the packets need to be followed until the end of the file. Once the starting position and length for all of the files on the disk has been determined it is simple to reconstruct the directory listing for the drive. The file names, creation date and time and close time cannot be restored but the actual file data will be accessible.

Another potential future improvement would be the creation of a Windows file system driver for the STANAG-4575 file system. The principle advantage of a file system driver is that it would make it possible for Windows Explorer and any other Windows program to directly access the files on a STANAG-4575 disk. Even if a file system driver is written, a utility like the Media Manager would still be required to format and declassify the STANAG-4575 disks.

CONCLUSION

The STANAG-4575 file system is an excellent file system for flight test data recorders. By creating the Media Manager application, TTC has addressed one of the problems that users typically encounter when they want to use Chapter 10 recorders with standard PCs.

The Media Manager application provides all of the essential features that a user needs to transfer data files from a Chapter 10 recorder to their PC. This allows the data to be analyzed after a test flight and it allows the removable memory cartridge to be quickly reused on subsequent flights.

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