ABSTRACT
Controlling access to your data and keeping track of any changes to it is becoming an increasingly important task. A lot is at risk when data becomes compromised, and depending on the event, regulators may become involved. This paper looks at a way that SAS provides of controlling who has access to the datasets for modification, and also looks at two alternatives for tracking changes, first through an audit trail and second using SAS dataset "versioning".

INTRODUCTION
Since SAS version 8 was first released the ability to do an audit trail on a SAS dataset has been available to the SAS user. With this new feature and the existing SAS options to control viewing and modification of data, SAS provides the user to have control over their most valuable asset, their data. While there are other applications out there that will track changes of SAS datasets, the features provided by SAS are robust enough for users to at least consider SAS as a possible answer to keeping track of changes to their data.

It must be noted from the onset that the idea of adding an audit trail to a SAS dataset is to track changes and modifications - rebuilding the dataset deletes any existing audit trail.

SAS OPTIONS
There are four SAS Options that are very good for controlling access to a SAS dataset:

- ALTER= password to alter structure
- READ= password to read
- WRITE= password to modify the data
- ENCRYPT= password to encrypt the data

These passwords can be set when the dataset is first created. While there are the four options, in practice on a controlled network only two of these options are used, ALTER and WRITE, as to put READ and ENCRYPT passwords on a SAS dataset will require all users who want to view the data to have these passwords. Enabling only the ALTER and WRITE password will restrict altering the structure of the dataset, e.g. adding or deleting columns, and also restrict who can modify, add or delete data. The following example demonstrates adding ALTER and WRITE passwords to a SAS dataset that has information on medical monitors:

```sas
data trial.crew (alter=Navy write=Lark label='HMS Troutbridge');
  infile cards;
  input name $ 1-16 rank $ 18-36 sn $ 38-42;
  cards;
  Leslie Philips   Sub Lieutenant  61885
  Jon Pertwee     Chief Petty Officer 50796
  Ronnie Barker   Able Seaman 96822
  Dennis Price    Number One 52925
  Stephen Murray  Lieutenant 57467
  Richard Caldicot Commander 07973
; run;
```

Running a CONTENTS procedure will produce the following output indicating that the dataset has been protected with an ALTER and WRITE password:
The CONTENTS Procedure

Data Set Name        TRIAL.CREW                               Observations          6
Member Type          DATA                                     Variables             3
Engine               V9                                       Indexes               0
Created              Sunday, February 24, 2008 10:12:06 AM    Observation Length    40
Last Modified        Sunday, February 24, 2008 10:12:06 AM    Deleted Observations  0
Protection           WRITE/ALTER                              Compressed            NO
Data Set Type                                                 Sorted                NO
Label                HMS Troutbridge
Data Representation  WINDOWS_32                             Encoding             wlatin1  Western (Windows)

Alphabetic List of Variables and Attributes

<table>
<thead>
<tr>
<th>#</th>
<th>Variable</th>
<th>Type</th>
<th>Len</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>name</td>
<td>Char</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>rank</td>
<td>Char</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>sn</td>
<td>Char</td>
<td>5</td>
</tr>
</tbody>
</table>

With the ALTER and WRITE passwords in place only those who are privy to these would be able to alter the structure of the dataset or add, delete or modify the records.

GETTING THE AUDIT TRAIL STARTED IN A SAS DATASET

An audit trail is useful if the dataset is in a state where few if any changes are needed, or it is a dataset that is like a list that is constantly changing. It is not good for the case where the dataset will be rebuilt many times over the life of the dataset – in this case the user should consider versioning which is discussed later in this paper.

You start an audit trail using the AUDIT statement in the DATASETS procedure. The following initiates the audit trail to the dataset CREW:

```
proc datasets lib=trial;
    audit crew (alter=Navy);
    initiate;
    user_var reason $100;
quit;
run;
```

Note that a password had to be entered to alter the dataset. A variable REASON has also been created using the USER_VAR statement so that it is possible to put a note to a record that has been changed. The output from a CONTENTS procedure call will produce a similar output as before but with four extra lines added at the bottom of the header indicating that the dataset does have an audit trail, but it does not contain any of the variables used to store the audit information:

```
The CONTENTS Procedure

Data Set Name        TRIAL.CREW                               Observations          6
Member Type          DATA                                     Variables             3
Engine               V9                                       Indexes               0
Created              Sunday, February 24, 2008 10:12:06 AM    Observation Length    40
Last Modified        Sunday, February 24, 2008 10:12:06 AM    Deleted Observations  0
Protection           WRITE/ALTER                              Compressed            NO
Data Set Type                                                 Sorted                NO
Label                HMS Troutbridge
Audit                Active
Audit Before Image   YES
Audit Admin Image    YES
Audit Error Image    YES
Audit Data Image     YES
Data Representation  WINDOWS_32                             Encoding             wlatin1  Western (Windows)

Alphabetic List of Variables and Attributes

<table>
<thead>
<tr>
<th>#</th>
<th>Variable</th>
<th>Type</th>
<th>Len</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>name</td>
<td>Char</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>rank</td>
<td>Char</td>
<td>19</td>
</tr>
<tr>
<td>3</td>
<td>sn</td>
<td>Char</td>
<td>5</td>
</tr>
</tbody>
</table>
```

2
To get the audit trail variables for the dataset the TYPE=AUDIT option needs to be used in the CONTENTS procedure call, as shown below:

```sas
proc contents data=trial.crew (type=audit);
run;
```

with the following output:

```
The CONTENTS Procedure

Data Set Name          TRIAL.CREW.AUDIT                    Observations          0
Member Type            AUDIT                                   Variables             10
Engine                 V9                                      Indexes               0
Created                Sunday, February 24, 2008 10:17:31 AM    Observation Length    206
Last Modified          Sunday, February 24, 2008 10:17:31 AM    Deleted Observations  0
Protection             WRITE/ALTER                                 Compressed            NO
Data Set Type          AUDIT                                   Sorted                NO
Label                  HMS Troutbridge                        Data Set Type        AUDIT
Data Representation    WINDOWS_32                              Label                HMS Troutbridge
Encoding               wlatin1 Western (Windows)

Alphabetic List of Variables and Attributes

<table>
<thead>
<tr>
<th>#</th>
<th>Variable</th>
<th>Type</th>
<th>Len</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td><em>ATDATETIME</em></td>
<td>Num</td>
<td>8</td>
<td>DATETIME19.</td>
</tr>
<tr>
<td>10</td>
<td><em>ATMESSAGE</em></td>
<td>Char</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td><em>ATOBSNO</em></td>
<td>Num</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td><em>ATOPCODE</em></td>
<td>Char</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td><em>ATRETURNCODE</em></td>
<td>Num</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td><em>ATUSERID</em></td>
<td>Char</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>name</td>
<td>Char</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>rank</td>
<td>Char</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>reason</td>
<td>Char</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>sn</td>
<td>Char</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

Descriptions of the variables created for the audit trail are listed below:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>ATDATETIME</em></td>
<td>Date/time of modification</td>
</tr>
<tr>
<td><em>ATUSERID</em></td>
<td>User ID of person making modification</td>
</tr>
<tr>
<td><em>ATOBSNO</em></td>
<td>Observation number of record being modified (NOTE: if the option REUSE=YES is on then value will always be '0')</td>
</tr>
<tr>
<td><em>ATRETURNCODE</em></td>
<td>Success/Failure return code (blank if successful, error code from SAS Log if unsuccessful)</td>
</tr>
<tr>
<td><em>ATMESSAGE</em></td>
<td>Stores the SAS log message from SAS when the modification occurred</td>
</tr>
<tr>
<td><em>ATOPCODE</em></td>
<td>Modification code. Valid return codes are:</td>
</tr>
<tr>
<td></td>
<td>DA=Record added</td>
</tr>
<tr>
<td></td>
<td>DD=Record deleted</td>
</tr>
<tr>
<td></td>
<td>DR=Copy of record before update</td>
</tr>
<tr>
<td></td>
<td>DW=Copy of record after update</td>
</tr>
<tr>
<td></td>
<td>EA=Record added failure</td>
</tr>
<tr>
<td></td>
<td>ED=Record deleted failure</td>
</tr>
<tr>
<td></td>
<td>EW=Record update failure</td>
</tr>
<tr>
<td>REASON</td>
<td>User created variable for purpose of noting a reason.</td>
</tr>
</tbody>
</table>
```

It is possible to suspend, resume and terminate the audit trail for a dataset using the following code examples:
proc datasets lib=trial;
  *Suspend an audit trail;
    audit crew (alter=Navy); suspend;
  *Resume an audit trail;
    audit crew (alter=Navy); resume;
  *Terminate an audit trail;
    audit crew (alter=Navy); terminate;
quit;
run;

While it is possible to do these actions on an audit trail within a SAS dataset these are not encouraged since it will invalidate the integrity of the dataset.

TIME TO MODIFY SOME DATA WHEN AN AUDIT TRAIL IS ACTIVE

In the Introduction it was indicated that if a SAS Dataset was rebuilt then audit trail information pertaining to that dataset will be lost so some particular strategies have to be adopted when editing data in the SAS dataset.

The three tasks that are generally done in a SAS dataset are:

- modify an existing observation
- add a new observation
- delete an existing observation

Whenever a DATA step SET statement is used the dataset is rebuilt so using this statement in the code to modify the dataset should be highly discouraged. However the SQL procedure with UPDATE, INSERT and DELETE statements is one way of modifying the data while keeping the audit trail. The following examples show how to update the dataset while keeping the audit trail:

proc sql;
  *Correct record;
  update trial.crew (write='Lark')
    set name='Leslie Phillips',
         reason='Corrected name, ref. memo 2008-02-24'
    where sn='61885';

  *Delete record - update first to add reason;
  update trial.crew (write='Lark')
    set reason='On loan to US Navy, ref. memo 2008-02-24'
    where sn='52925';
  delete
    from trial.crew (write='Lark')
    where sn='52925';

  *Add new record;
  insert into trial.crew (write='Lark')
    set name='Heather Chasen',
         rank='WRN, First Class',
         sn='98072',
         reason='New crew member, ref. memo 2008-01-24';
quit;
run;

After the amendments the dataset has the following data:

<table>
<thead>
<tr>
<th>Obs</th>
<th>Name</th>
<th>Rank</th>
<th>Sn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Leslie Phillips</td>
<td>Sub Lieutenant</td>
<td>61885</td>
</tr>
<tr>
<td>2</td>
<td>Jon Pertwee</td>
<td>Chief Petty Officer</td>
<td>50796</td>
</tr>
<tr>
<td>3</td>
<td>Ronnie Barker</td>
<td>Able Seaman</td>
<td>96822</td>
</tr>
<tr>
<td>5</td>
<td>Stephen Murray</td>
<td>Lieutenant</td>
<td>57467</td>
</tr>
<tr>
<td>6</td>
<td>Richard Caldicot</td>
<td>Commander</td>
<td>07973</td>
</tr>
<tr>
<td>7</td>
<td>Heather Chasen</td>
<td>WRN, First Class</td>
<td>98072</td>
</tr>
</tbody>
</table>

To list the audit data the option TYPE=AUDIT must be used, as shown in the following SAS code and output:
proc print data=trial.crew (type=audit);
   title1 'Audit Trail After Modifying CREW Dataset';
run;

Audit Trail After Modifying CREW Dataset

<table>
<thead>
<tr>
<th>Obs</th>
<th>name</th>
<th>rank</th>
<th>sn</th>
<th>reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Leslie Philips</td>
<td>Sub Lieutenant</td>
<td>61885</td>
<td>Corrected name, ref. memo 2008-02-24</td>
</tr>
<tr>
<td>2</td>
<td>Leslie Phillips</td>
<td>Sub Lieutenant</td>
<td>61885</td>
<td>Corrected name, ref. memo 2008-02-24</td>
</tr>
<tr>
<td>3</td>
<td>Dennis Price</td>
<td>Number One</td>
<td>52925</td>
<td>On loan to US Navy, ref. memo 2008-02-24</td>
</tr>
<tr>
<td>4</td>
<td>Dennis Price</td>
<td>Number One</td>
<td>52925</td>
<td>On loan to US Navy, ref. memo 2008-02-24</td>
</tr>
<tr>
<td>5</td>
<td>Dennis Price</td>
<td>Number One</td>
<td>52925</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Heather Chasen</td>
<td>WRN, First Class</td>
<td>98072</td>
<td>New crew member, ref. memo 2008-01-24</td>
</tr>
</tbody>
</table>

Note that in the listing from the audit trail it recorded that the record for SN 61885 was changed, the record for SN 52925 was deleted (it was actually modified first to get a reason for deletion in the audit trail) and a new record for SN 98072 was added. Also added was the UserID of the person who added it and the date/time it occurred.

ANOTHER WAY TO TRACK CHANGES, DATASET VERSIONING

As mentioned earlier the audit information is lost when a SAS dataset is rebuilt using a statement like SET in the DATA step. However it is sometimes necessary to keep versions of a SAS dataset. This can be achieved using the SAS DATASETS procedure with the COPY statement and placing that copy into another directory or placing it on another media.

SAS has another feature that is available if “versions” of a dataset have to be made instead of using the audit trail facilities. To set a SAS dataset up for “versions” the GENMAX= option is invoked, as shown in the example below:

data trial.crew (alter=Navy write=Lark label='HMS Troutbridge' genmax=2);
   infile cards;
      input name $ 1-16 rank $ 18-36 sn $ 38-42;
   cards;
   Leslie Philips   Sub Lieutenant      61885
   Jon Pertwee      Chief Petty Officer 50796
   Ronnie Barker    Able Seaman         96822
   Dennis Price     Number One          52925
   Stephen Murray   Lieutenant          57467
   Richard Caldicot Commander           07973
   ;
run;

The GENMAX=2 statement allows for three versions of the dataset to exist at any one time with number 0 as the current version, 2 as the most recent version, and 1 as the oldest version. A maximum of 999 versions, excluding the latest version, can be set for a dataset with the oldest version “dropping off” if the new version is created and the number of versions exceed that allowable.

To access a particular version of a dataset the option GENNUM= is used and can be used both in a direct and relative reference, as the following examples show:

*Print current version of dataset;
 proc print data=trial.crew;
 run;

*Print previous version of dataset;
 proc print data=trial.crew (gennum=-1);
 run;
Using this same technique it is possible to use the COMPARE procedure and compare versions of a dataset using the following code:

```sas
proc compare base=trial.crew data=trial.crew (gennum=-1);
run;
```

Versions of a SAS dataset can be deleted using the DELETE statement in the DATASETS procedure, as the following example shows:

```sas
proc datasets library=trial;
 *Deletes all versions except current version;
   delete crew (gennum=hist);
 *Deletes current version and moves previous version to current;
   delete crew;
 *Deletes all versions of dataset;
   delete crew (gennum=all);
quit;
run;
```

The main disadvantage of using this method is that no note is available as to why a version was needed or any record as to why an individual observation was changed. However changes can be quickly seen using tools like the COMPARE procedure.

**CONCLUSION**

With careful planning it is possible to use SAS for tracking and securing SAS datasets. The methods looked at here are good and can track changes using their own features but it is important to know that with each method there are limitations.

**CONTACT INFORMATION**

Your comments and questions are valued and encouraged. Contact the author at:

David Franklin  
16 Roberts Road  
Litchfield, NH 03052  
Tel/Fax 603/216-2232  
Email 100316.3451@compuserve.com  
http://ourworld.compuserve.com/homepages/dfranklinuk

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