ABSTRACT
You have successfully created a SAS® program that processes data and generates reports for a series items in the data. The program itself works fine, but the problem is that each time the program is executed, it must be manually modified specifically for that run. Perhaps the analysis variable changes or perhaps the name of the report’s PDF file must reflect the name of the incoming data set. Making manual changes once in awhile is bothersome, but not onerous. But if find yourself making a great many of these manual changes, the process becomes both tedious and error prone.

Through the use of the macro language, SAS has the power make the necessary changes on the fly, automatically, without manual intervention. Learning how to convert a program from one that needs manual modifications to one that adjusts and runs automatically is not difficult. Not difficult that is, if you know the steps. This paper walks you through the steps, that you can follow, to convert your program’s transmission from manual to automatic.

KEY WORDS
macro language, automated program, dynamic process, data driven

INTRODUCTION
The ability to creating an automated program or process is learned. You will not absorb it at night while you sleep, you can not ingest it with your Cheerios™ at breakfast, and you will not stumble on it. While the bottom line is that it is not intuitively obvious, it is not particularly difficult to master.

The key to automating a SAS program is the ability to build and process a list of activities. In the paper “List Processing Basics: Creating and Using Lists of Macro Variables” by Ron Fehd and Art Carpenter, four different techniques of list creation and management are discussed. The “List Processing Basics” paper and the one that you are currently reading, cover much of the same material, however the “List Processing Basics” paper concentrates on the process of list building, rather than explicitly discussing the overall process of program automation. After finishing this paper, I highly recommend that you read the “List Processing Basics” paper for numerous details that will not be covered here.

In this paper I will attempt a more simplified approach to the topic from a different direction.

MAKING A LIST
Before you can successfully automate your program, you will need to be able to define what is to be done in terms of a list. The examples in this paper are for a report that is to be executed for each of a number of different countries. We therefore need to be able to build that list of countries so that the program will
automatically execute for each country on the list.

What do I mean by a ‘list’? Well actually, nothing special at all. You have created numerous lists of things to do and to buy, and the lists that will be created in the automation process are only different in that they utilize the macro language.

Most of us create lists for our errands. If we are to buy groceries, we may create a list such as one of the following two lists.

- eggs
- butter
- milk
- cheerios

A list of vertical values is probably most common, however there is no reason why the list could not have been written horizontally as well. Both work equally well as a shopping list, and both have application to the automation process.

The lists that we use in our SAS program will be stored through the use of the macro language and macro variables. A vertical list will be stored using a series of macro variables each containing one item, and the horizontal list is stored in a single macro variable.

%let item1 = eggs;
%let item2 = butter;
%let item3 = milk;
%let item4 = cheerios;

Of course if we have to build each macro variable by hand we will not have saved ourselves much work - still too manual. So let’s look at a couple of ways that SAS can build macro variable lists. Remember there are other ways to create lists, other ways than just the two shown here.

For the automated process the information that is to be used to generate the list has to come from somewhere. In the examples shown here and below, the list comes from the data, but there are many places that you can find information to feed the automation process (see the section on Information Sources later in this paper for more on this topic).

Creating a List of Variables - The Vertical List
The ‘vertical list’ is made up of one macro variable for each item that is to be stored. The list can easily be created in a DATA step or in a PROC SQL step.

data list;
  buy='eggs' ; output list;
  buy='butter' ; output list;
  buy='milk' ; output list;
  buy='cheerios' ; output list;
run;

First let’s build a data set which contains our list (one observation per item). The variable BUY contains the item of interest, and it is this value that we want to place into the macro variable.

The list of macro variables can be created in
data _null_;  
set list;  
i = left(put(_n_,4.));  
call symputx('item'||i,buy);  
call symputx('numitems',i);  
run;

proc sql noprint;  
select buy 
into :item1 - :item999 
from list;  
quit;

%let numitems = &sqlobs;

data _null_;  
set list;  
i = left(put(_n_,4.));  
call symputx('item'||i,buy);  
call symputx('numitems',i);  
run;

proc sql noprint;  
select buy 
into :itemlist separated by ' ' 
from list;  
quit;

%let numitems = &sqlobs;

1. Read the items one at a time from the incoming data set containing the shopping list.
2. Create a character variable that contains the item number.
3. Store the individual items to buy in a macro variable of the form ITEMi.
4. Save the number of items in the list in the macro variable &NUMITEMS. &SQLOBS is an automatic counter generated during processing of the SQL step.

In the DATA step we use the SYMPUTX routine to write the macro variables to the macro symbol table, while in the SQL step the INTO phrase (along with a colon in front of the new macro variable) is used.

Creating a Variable with a List - The Horizontal List
A horizontal list is best stored in a single macro variable. In this form of the list the individual items are stored as words within the list. This implies that there needs to be a word separator that is distinct from the values being stored (a comma will not work if an item contains a comma).

While the DATA step can be used to build this type of list, it is much easier to do it in a SQL step. The key is the SEPARATED BY phrase. This allows SQL to enter multiple values into the macro variable &ITEMLIST, with the individual words separated by blanks.

USING A MACRO VARIABLE LIST
Now that we have built either a vertical or horizontal list of values, we need to be able to use them. In our program. For our shopping list analogy we wrote the list on a piece of paper so we could go shopping, and once at the store we read the list. In our program there are multiple ways to read our list, but usually it will involve the use of a macro %DO loop of one kind or another.

The macro language does not support arrays, there is no %ARRAY statement, however this type of processing is similar to what is done with a singly dimensioned array. The list is a vector of values, which is accessed one value at a time.

Processing a List of Macro Variables - Vertical List
Vertical lists are generally processed with an iterative %DO loop. The loop’s index also serves as the index to the list of values. Since a %DO can not appear in open code it will be written inside of a macro. In this example we are only using a %PUT to write to the LOG.
%macro writeVertical;
%local i;
%* Write the vertical list;
%do i = 1 %to &numitems;
  %put item &i is &item&i;
%end;
%mend writevertical;

%writevertical

132 item 1 is eggs
item 2 is butter
item 3 is milk
item 4 is cheerios

1 Be sure to force the %DO loop index onto the local symbol table unless you have a really really good reason for not doing so (Carpenter, 2005).
2 The iterative %DO ranges from 1 to the number of items in the list (&numitems).
3 The %PUT will be executed for each item on the shopping list. Double ampersands, &&, resolve to a single ampersand. It takes two passes for &&item&i to be resolved to the shopping list item.

<table>
<thead>
<tr>
<th>&amp;i</th>
<th>&amp;&amp;item&amp;i becomes</th>
<th>list item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&amp;item1</td>
<td>eggs</td>
</tr>
<tr>
<td>2</td>
<td>&amp;item2</td>
<td>butter</td>
</tr>
<tr>
<td>3</td>
<td>&amp;item3</td>
<td>milk</td>
</tr>
<tr>
<td>4</td>
<td>&amp;item4</td>
<td>cheerios</td>
</tr>
</tbody>
</table>

4 The LOG shows the four items from the shopping list.

Processing a Macro Variable Containing a List - Horizontal List
When you use a horizontal list, you will need fewer ampersands than for the vertical list, but the code to extract the individual words will be more complex.

We will still be using a %DO to step through the list of values however this time we will also need to get the individual words from the overall list of words. The %SCAN function is designed to extract the i\textsuperscript{th} word and will be perfect for the task. When we know the total number of items in the list an iterative %DO can be used as in the previous example. However often when dealing with a horizontal list we often do not know how many items it contains, and a %DO %WHILE is used instead of a iterative %DO. Just for demonstration purposes, the following example uses the slightly more complex %DO %WHILE.

%macro writehorizontal;
%local i item;
%* Write the horizontal list;
%let i=0;
%do %while(%qscan(&itemlist,&i+1,%str( )) ne %str( ));
  %let i = %eval(&i+1);
  %let item = %qscan(&itemlist,&i,%str( ));
  %put Item &i is &item;
%end;
%mend writehorizontal;

%writehorizontal

143 Item 1 is eggs
Item 2 is butter
Item 3 is milk
Item 4 is cheerios

The LOG shows:
THE 6 STEP PROGRAM
Most programs that build and process a list have certain elements. Initially, as you learn to create programs that run themselves automatically, make a conscious effort to make sure that these elements exist in your program. They may not be intuitive as you learn, however as you get proficient building this type of program the elements themselves become automatic.

1) Identify a source for the information that will drive the process.
2) Generalize or write your program to accept a macro variable list.
3) Use a %DO loop to process across all the items in the list.
4) Within the loop, access the individual elements of the list by using either:
   &&item&i  Vertical list (one macro variable per item)
   %qscan(&itemlist,&i,%str( )) Horizontal list (one macro variable - each word is an item)
5) Build a list of macro variables (or a macro variable containing the list). Vertical or horizontal list, its your choice.
6) For vertical lists (a list of macro variables), be sure to count the number of elements in the list.

It is common when first learning to build an automatic program to want to convert it from one that runs manually. As you make the conversion be sure that you account for each of the above steps.

CONVERSION
Once you are comfortable with dynamic programming techniques, you will be able to build programs that execute automatically from scratch. However for most programmers it is easiest to see how to apply the six steps shown above, by starting with a manual program and converting it step by step. The following PROC REPORT step is taken from the paper by Fehd and Carpenter (2007), and it will be used here to illustrate the step by step process for the conversion from manual to automatic.

```sas
title1 'shoe data';
proc print
data=sashelp.shoes(obs=30);
var region product subsidiary sales;
run;
```

In this example we will examine the shoe sales data in SASHELP. The data set itself is fairly simple with sales information for
various products from various regions of the world and subsidiaries within region.

<table>
<thead>
<tr>
<th>Obs</th>
<th>Region</th>
<th>Product</th>
<th>Subsidiary</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Africa</td>
<td>Boot</td>
<td>Addis Ababa</td>
<td>$29,761</td>
</tr>
<tr>
<td>2</td>
<td>Africa</td>
<td>Men's Casual</td>
<td>Addis Ababa</td>
<td>$67,242</td>
</tr>
<tr>
<td>3</td>
<td>Africa</td>
<td>Men's Dress</td>
<td>Addis Ababa</td>
<td>$76,793</td>
</tr>
<tr>
<td>4</td>
<td>Africa</td>
<td>Sandal</td>
<td>Addis Ababa</td>
<td>$62,819</td>
</tr>
<tr>
<td>5</td>
<td>Africa</td>
<td>Slipper</td>
<td>Addis Ababa</td>
<td>$68,641</td>
</tr>
<tr>
<td>6</td>
<td>Africa</td>
<td>Sport Shoe</td>
<td>Addis Ababa</td>
<td>$1,690</td>
</tr>
<tr>
<td>7</td>
<td>Africa</td>
<td>Women's Casual</td>
<td>Addis Ababa</td>
<td>$51,541</td>
</tr>
<tr>
<td>8</td>
<td>Africa</td>
<td>Women's Dress</td>
<td>Addis Ababa</td>
<td>$108,942</td>
</tr>
</tbody>
</table>

... portions of the listing is not shown ...
to write the REPORT step so that it could execute for any region.

Clearly we still need to manually change the value of &REG for each region, however now we only need to make the change in one place.

```
%let reg = Africa;
%let reg = Asia;
%let reg = Canada;
Title "Sales in &reg";
PROC Report data = sashelp.Shoes nowd;
where region = "&reg";
column product subsidiary, sales;
define product / group;
define subsidiary / across;
define sales / analysis '';
run;
```

As we determine the names of the regions, that is the values of the variable REGION, we can create a %LET statement for each value. At any given time the ones that are not to be used are commented out.

Now all we have to do is uncomment the region of choice. Even this process, however is still fairly manual, and we still have to 'know' all the values that are taken on by the variable REGION. For a large number of values this becomes awkward and unwieldily at best.

As you generalize anticipate what your program will need to look like in order for it to take advantage of the macro variable list.

3) Use a %DO loop to process across all the items in the list.
4) Within the loop, access the individual elements of the list by using &&VAR&I.

```
%do r = 1 %to &regcnt;
    Title "Sales in &&reg&r";
    PROC Report data = sashelp.Shoes nowd;
    where region = "&&reg&r";
    column product subsidiary, sales;
    define product / group;
    define subsidiary / across;
    define sales / analysis '';
    run;
%end;
```

Clearly we want to execute the REPORT step a number of times for a list of regions. A %DO loop is added to surround the repeated step and the values of the variable REGION refer to a list of macro variables of the form: &REG1, &REG2, &reg3, etc.

Because we are addressing a list of macro variables (a vertical list) the list is addressed using &REG&I.

5) Build a list of macro variables

Because of how we built the loop and referenced the list, we need to build a list of macro variables, each with one value of REGION.

```
proc sql noprint;
    select distinct region
    into :reg1 - :reg999
    from sashelp.shoes;
quit;
```

This PROC SQL step writes up to 999 macro variables of the form &REG1, &REG2, etc. Each will have a unique value of REGION.
Count the number of elements in the list.
Our iterative %DO loop will need to have an upper bound that matches the number of regions.

```sql
proc sql noprint;
   select distinct region
     into :reg1 - :reg999
     from sashelp.shoes;
quit;
%let regcnt = &sqlobs;
```

Since we have used an SQL step to build the macro variable list, we can take advantage of the automatic macro variable &SQLOBS. This macro variable is assigned a value each time an SQL statement such as SELECT is executed. In this example &SQLOBS holds the number of distinct regions.

Because &SQLOBS is reset by most SQL statements, it is always best to save the value in a macro variable of your choosing. Here we are using &REGCNT.

```sql
%macro SalesRpt;
%local r;
proc sql noprint;
   select distinct region
     into :reglist separated by '*'
     from sashelp.shoes;
quit;
%let r = 0;
%do %while (%qscan(&reglist,&r+1,*) ne );
   %let r = %eval(&r+1);
   %let reg = %qscan(&reglist,&r,*);
   Title "Sales in &reg";
   PROC Report data = sashelp.Shoes nowd;
      column product subsidiary, sales;
      define product / group;
      define subsidiary / across;
      define sales / analysis '';
      run;
%end;
%mend salesrpt;
```

In the previous macro we built the list of regions by creating a list of macro variables (vertical list). The horizontal list could have also have been implemented by creating a single macro variable with each region stored as a word. The resulting code becomes:

```sql
%macro SalesRpt;
%local r;
proc sql noprint;
   select distinct region
     into :reglist separated by '*'
     from sashelp.shoes;
quit;
%let r = 0;
%do %while (%qscan(&reglist,&r+1,*) ne );
   %let r = %eval(&r+1);
   %let reg = %qscan(&reglist,&r,*);
   Title "Sales in &reg";
   PROC Report data = sashelp.Shoes nowd;
      where region = "&reg";
      column product subsidiary, sales;
      define product / group;
      define subsidiary / across;
      define sales / analysis '';
      run;
%end;
%mend salesrpt;
```
left assumes that the number of regions is unknown.

The individual words are determined one at a time using the %QSCAN function. This simplifies the macro variable call in the TITLE and WHERE statements at the expense of the more complex %QSCAN.

INFORMATION SOURCES
In each of the previous examples the information needed to build the list of macro variables was obtained from the data being analyzed. Fortunately, since not all of our tasks are driven by the analysis data, there are a number of other sources of information that can be used to build the macro variable lists.

- Control data sets built strictly to control macro operations
- The analysis data itself
- A table that looks like or acts like a data table, this might include something like an EXCEL spreadsheet
- OUT= option with PROC CONTENTS
- SASHELP and Dictionary views
- Results of operating system operations
- SAS system option settings
- SAS DATA step functions

Essentially any data set, function, or option that returns a value can become a source of information for an program that is to operate automatically. There are many examples of macros that take advantage of the sources just listed. You need to become familiar with each of these and you may even discover some more of your own. As you use them, notice that in each case your program will include most, if not all, of the elements of an automated program discussed earlier.

SUMMARY
Programs that require manual intervention are more costly to maintain and are more error prone than those that automatically adjust to the task. Converting your programs from manual to automatic is not always straightforward, but the benefit can be huge. By following the steps outlined in this paper, you can successfully convert, write, and understand automated programs.

The automated aspects of your programs may be based on the analysis data or on one or more other sources of information. Learn about these sources of information and learn how to use them. Practice.

You too can move up from manual to automatic!

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Art Carpenter’s publications list includes four books, and numerous papers and posters presented at SUGI, SAS Global Forum, and other user group conferences. Art has been using SAS® since 1977 and has served in various leadership positions in local, regional, national, and international user groups. He is a SAS Certified Advanced Professional Programmer, and through California Occidental Consultants he teaches SAS courses and provides contract SAS programming support nationwide.

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**REFERENCES**


Fehd, Ronald and Art Carpenter, 2007, The same data set and REPORT step is shown in the paper “List Processing Basics: Creating and Using Lists of Macro Variables” by Ronald Fehd and Art Carpenter which was presented at the 2007 SAS Global Forum (Paper 113-2007). The discussion of the paper looks at different approaches used in the automation of programs by using various kinds of macro variable lists. This paper appears in proceedings of a number of conference, including: SGF(2007), WUSS (2008), MWSUG (2009), SESUG (2009).

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