The inner workings of the datastep

By Mathieu Gaouette

Plan

- Introduction
- The base
- The base behind the scene
- Control in the datastep
- A side by side compare with Proc SQL

Introduction

- Most of you probably have been introduced to SAS through Proc SQL.
- Unless you have been taught (or have read) about the datastep, most of you probably very rarely use it.
- Do you think you could name one thing that can be done with a datastep that can't be performed with a proc SQL?
- Knowledge of how the datastep is being processed by SAS is key in using it wisely.

The base

The anatomy of the datastep is fairly simple:

Data **<table(s) to create >** ;

<Stuff! (input definition, functions, calculations, ...)>

Run ;

The base - Input

	SAS table input	Flat file input
Identification	**Set or merge statement** <set|merge> *table1 table2* … [options];	**Infile statement** <infile> *external-file* [options];
Input instruction	Same statement	Input statement

- Reading in data makes the datastep loop over as long as there is data to read…
  in most cases

The base - Output

	SAS table output	Flat file output
Identification	**Data statement** *Data table1 table2 … ;*	**File statement** *<File> external-file [options];*
Output instruction	*output [table-name] ;*	put statement

ℹ For SAS tables, if no explicit output is used, an implicit output statement is executed when the datastep execution hits the « run » statement.

Behind the scene

- Data step processing order
- Program data vector (PDV)
- Automatic PDV variables
- Detailed step by step example

Processing the datastep

1. The datastep initiates
2. If required, an input buffer is created
3. A program data vector is created (PDV)
4. The output dataset(s) are created empty

Only then is the first line
of the datastep is actually processed.

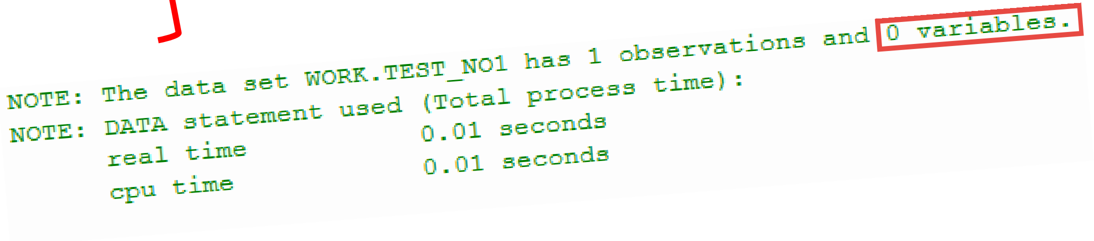
Why is that important?

The actual locations of a few key statements are irrelevant in a datastep.

Consider the following datastep:

```
data test_no1 ;
   val_a = 1 ; val_b = 2 ;
   if val_a = 3 then do ;
      drop val_a ;
   end ;
   else if val_b = 3 then do ;
      drop val_b ;
   end ;
run ;
```

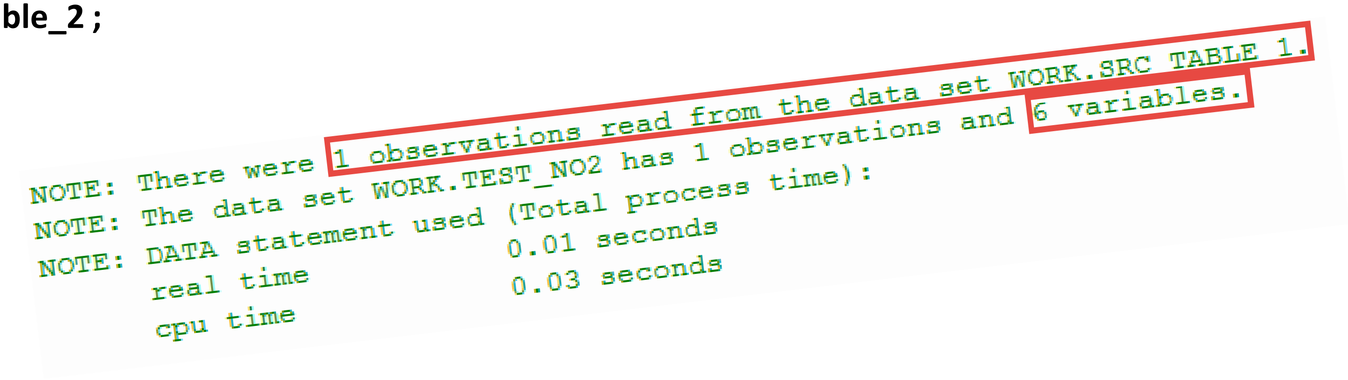
None of these two sub sections get executed



```
NOTE: The data set WORK.TEST_NO1 has 1 observations and 0 variables.
NOTE: DATA statement used (Total process time):
      real time           0.01 seconds
      cpu time            0.01 seconds
```

Another example

```
data src_table_1 ;
   val1_a = 1 ; val1_b = 1 ; val1_c = 1 ;
run ;
data src_table_2 ;
   val2_a = 2 ; val2_b = 2 ; val2_c = 2 ;
run ;
data test_no2 ;
   if "&SYSUSERID." eq 'gaouettm' then set src_table_1 ;
   else set src_table_2 ;
run ;
```



```
NOTE: There were 1 observations read from the data set WORK.SRC_TABLE_1.
NOTE: The data set WORK.TEST_NO2 has 1 observations and 6 variables.
NOTE: DATA statement used (Total process time):
      real time           0.01 seconds
      cpu time            0.03 seconds
```

A closer look at the PDV

- The PDV should be viewed as a draft of your data.
- It contains all of your dataset variables (even dropped variables) plus two system variables :
  1. _N_
  2. _ERROR_
- Knowing about these two system variables can be an asset.

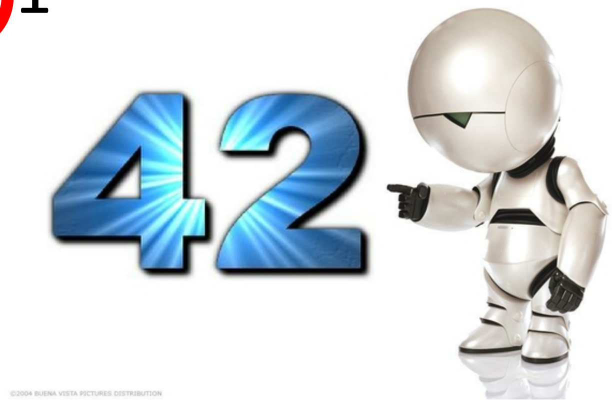
QUIZ

- What is the minimal possible value of the datastep system variable _N_?

A) 0

[✓ B) 1]

C)



_N_

- Contrary to popular belief, this system variable doesn't track the row number being processed.
- "Each time the DATA step loops past the DATA statement, the variable _N_ increments by 1. The value of _N_ represents the number of times the DATA step has iterated." (SAS.com)

- It's actually more: "The value of _N_ represents the number of times the DATA step has iterated **plus one**."

Typical use of _N_

- Limit the number of iteration in a datastep :

```
if _n_ > 1000 then stop ;
```

- Perform one time task from within the datastep :

```
if _n_ = 1 then do ;
        <code to be executed one time>
end ;
```

- Create an incremental id variable :

```
id_key = _n_ ;
```

ERROR

- is 0 by default but is set to 1 whenever an error is encountered, such as an input data error, a conversion error, or a math error, as in division by 0 or a floating point overflow. You can use the value of this variable to help locate errors in data records and to print an error message to the SAS log. (SAS.com)

QUIZ

- When a « _ERROR_ » is produced in a datastep, does SAS generates a « WARNING: » and/or « ERROR: » in the log?

A) Yes

B) No

[✓ C)] *It’s complicated. I’d rather not talk about it*

What triggers _ERROR_

A few common situations are:

- Divisions by zero
  - only triggers a **NOTE** in the log
- Invalid array position reference
  - triggers an **ERROR** in the log
- Invalid value for input/put function
  - only triggers a **NOTE** in the log

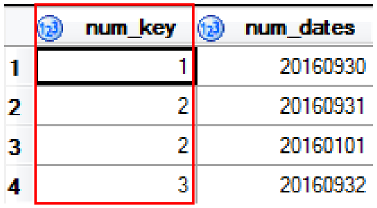
A note about NOTEs

- You can use input with an option that suppresses the errors.
  - A single ‘?’ with a space before the format tells SAS to not print the NOTE.
  - A double ‘?’ with a space before the format will also reset the _ERROR_ value to 0

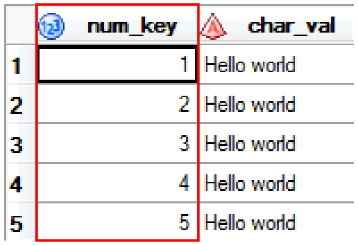
Ex: n_date = input(c_date,?? yymmdd10.) ;

Detailed example

- Lets start with two simple tables …that share a common key
- We wish to merge then and try to convert the « num_dates » into a SAS date.



	num_key	num_dates
1	1	20160930
2	2	20160931
3	2	20160101
4	3	20160932



	num_key	char_val
1	1	Hello world
2	2	Hello world
3	3	Hello world
4	4	Hello world
5	5	Hello world

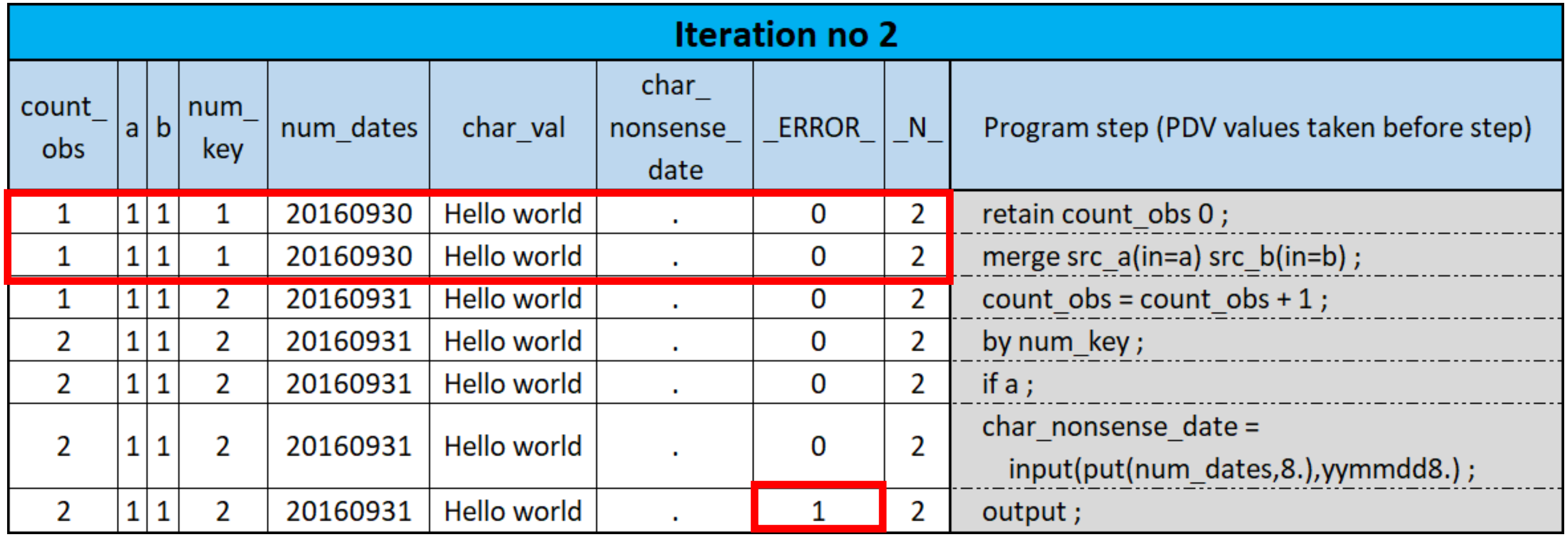
```
data toto ;
   retain count_obs 0 ;
   merge src_a(in=a) src_b(in=b) ;
   count_obs = count_obs + 1 ;
   by num_key ;
   if a ;
   char_nonsense_date = input(put(num_dates,8.),yymmdd8.) ;
   output ;
run ;
```

Lets keep an eye on the PDV

Iteration no 1									
count_ obs	a	b	num_ key	num_dates	char_val	char_ nonsense_ date	_ERROR_	_N_	Program step (PDV values taken before step)
0	0	0	.	.		.	0	1	retain count_obs 0 ;
0	0	0	.	.		.	0	1	merge src_a(in=a) src_b(in=b) ;
0	1	1	1	20160930	Hello world	.	0	1	count_obs = count_obs + 1 ;
1	1	1	1	20160930	Hello world	.	0	1	by num_key ;
1	1	1	1	20160930	Hello world	.	0	1	if a ;
1	1	1	1	20160930	Hello world	.	0	1	char_nonsense_date = input(put(num_dates,8.),yymmdd8.) ;
1	1	1	1	20160930	Hello world	20727	0	1	output ;

- Retained count_obs is initialized before the statement is executed.
- Input variables are set to missing until data is read.
- Char_nonsense_date actually gets a decent date value assigned.

Lets keep an eye on the PDV



Iteration no 2									
count_ obs	a	b	num_ key	num_dates	char_val	char_ nonsense_ date	_ERROR_	_N_	Program step (PDV values taken before step)
1	1	1	1	20160930	Hello world	.	0	2	retain count_obs 0 ;
1	1	1	1	20160930	Hello world	.	0	2	merge src_a(in=a) src_b(in=b) ;
1	1	1	2	20160931	Hello world	.	0	2	count_obs = count_obs + 1 ;
2	1	1	2	20160931	Hello world	.	0	2	by num_key ;
2	1	1	2	20160931	Hello world	.	0	2	if a ;
2	1	1	2	20160931	Hello world	.	0	2	char_nonsense_date = input(put(num_dates,8.),yymmdd8.) ;
2	1	1	2	20160931	Hello world	.	1	2	output ;

- First row of values are kept in PDV until merge statement is executed.
- Date conversion fails so _ERROR_ is set to 1 and the following note gets displayed in log:

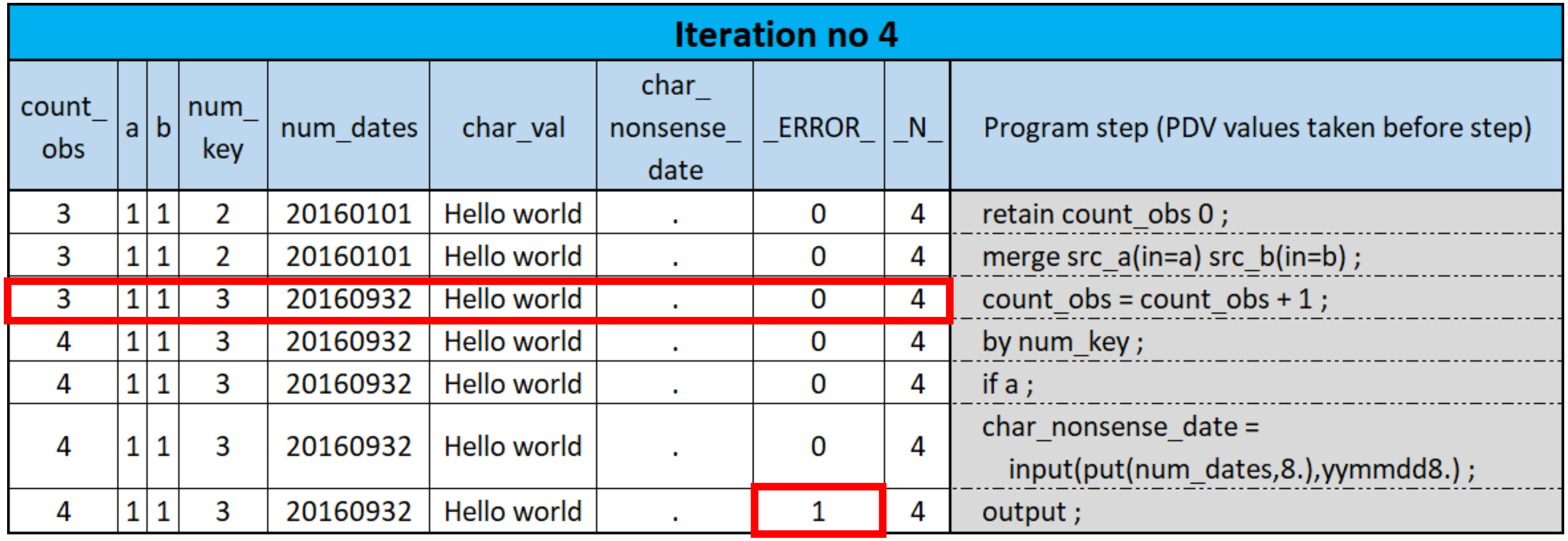
NOTE: Invalid argument to function INPUT at line 53 column 26.

Lets keep an eye on the PDV

Iteration no 3									
count_ obs	a	b	num_ key	num_dates	char_val	char_ nonsense_ date	_ERROR_	_N_	Program step (PDV values taken before step)
2	1	1	2	20160931	Hello world	.	0	3	retain count_obs 0 ;
2	1	1	2	20160931	Hello world	.	0	3	merge src_a(in=a) src_b(in=b) ;
2	1	1	2	20160101	Hello world	.	0	3	count_obs = count_obs + 1 ;
3	1	1	2	20160101	Hello world	.	0	3	by num_key ;
3	1	1	2	20160101	Hello world	.	0	3	if a ;
3	1	1	2	20160101	Hello world	.	0	3	char_nonsense_date = input(put(num_dates,8.),yymmdd8.) ;
3	1	1	2	20160101	Hello world	20454	0	3	output ;

- 3rd iteration starts off fresh with _ERROR_ back to 0.
- Second line of data for num_key 2 read (only the num_dates field changes). The pointer to the table src_b still points to the same row (num_key of 2).

Lets keep an eye on the PDV



Iteration no 4

count_ obs	a	b	num_ key	num_dates	char_val	char_ nonsense_ date	_ERROR_	_N_	Program step (PDV values taken before step)
3	1	1	2	20160101	Hello world	.	0	4	retain count_obs 0 ;
3	1	1	2	20160101	Hello world	.	0	4	merge src_a(in=a) src_b(in=b) ;
3	1	1	3	20160932	Hello world	.	0	4	count_obs = count_obs + 1 ;
4	1	1	3	20160932	Hello world	.	0	4	by num_key ;
4	1	1	3	20160932	Hello world	.	0	4	if a ;
4	1	1	3	20160932	Hello world	.	0	4	char_nonsense_date = input(put(num_dates,8.),yymmdd8.) ;
4	1	1	3	20160932	Hello world	.	1	4	output ;

- This iteration behaves a lot like the second one.
- A new line of data corresponding to a new num_key value is read from both tables.
- An error is encountered while converting the bogus date.

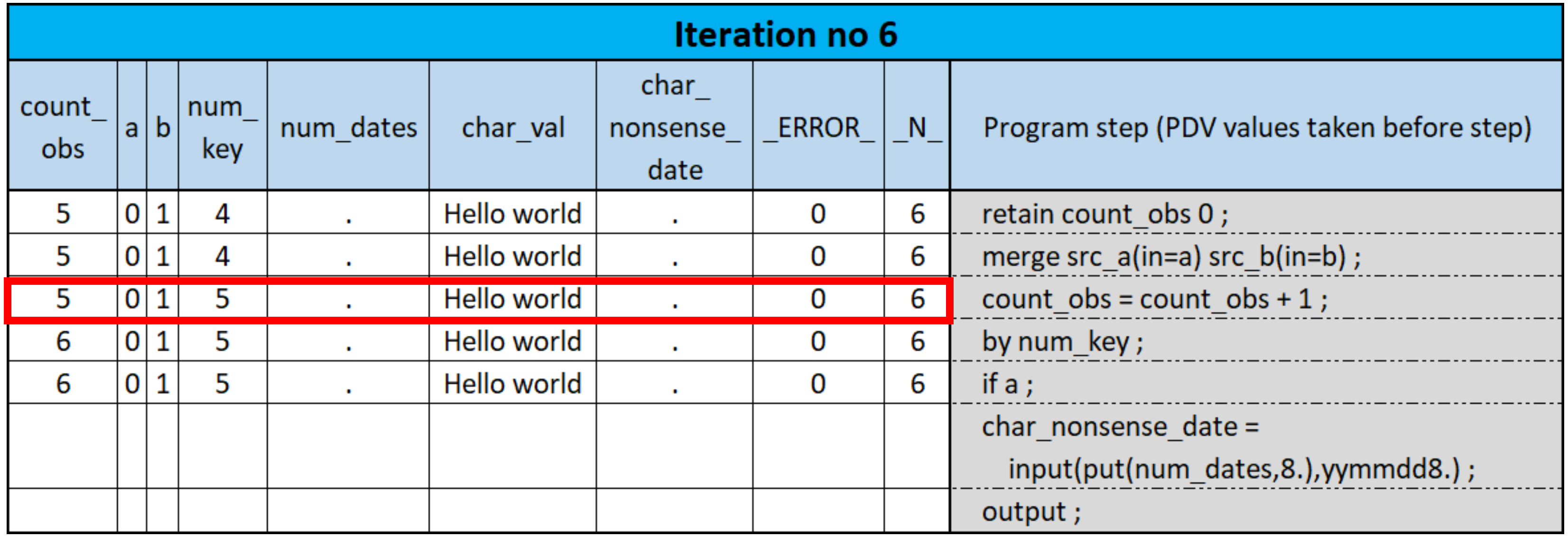
Lets keep an eye on the PDV

Iteration no 5

count_ obs	a	b	num_ key	num_dates	char_val	char_ nonsense_ date	_ERROR_	_N_	Program step (PDV values taken before step)
4	1	1	3	20160932	Hello world	.	0	5	retain count_obs 0 ;
4	1	1	3	20160932	Hello world	.	0	5	merge src_a(in=a) src_b(in=b) ;
4	0	1	4	.	Hello world	.	0	5	count_obs = count_obs + 1 ;
5	0	1	4	.	Hello world	.	0	5	by num_key ;
5	0	1	4	.	Hello world	.	0	5	if a ;
									char_nonsense_date = input(put(num_dates,8.),yymmdd8.) ;
									output ;

- _ERROR_ initialized again.
- Missing values for variables from table src_a as it does not contain the num_key 4.
- As “in variable” a is equal to 0, iteration stops there.

Lets keep an eye on the PDV



Iteration no 6									
count_obs	a	b	num_key	num_dates	char_val	char_nonsense_date	_ERROR_	_N_	Program step (PDV values taken before step)
5	0	1	4	.	Hello world	.	0	6	retain count_obs 0 ;
5	0	1	4	.	Hello world	.	0	6	merge src_a(in=a) src_b(in=b) ;
5	0	1	5	.	Hello world	.	0	6	count_obs = count_obs + 1 ;
6	0	1	5	.	Hello world	.	0	6	by num_key ;
6	0	1	5	.	Hello world	.	0	6	if a ;
									char_nonsense_date = input(put(num_dates,8.),yymmdd8.) ;
									output ;

- Again, missing values for variables from table src_a as it does not contain the num_key 5.
- As "in variable" a is equal to 0, iteration stops there and we are done with the datastep, right ?
- Wrong, almost done!

Lets keep an eye on the PDV

Iteration no 7									
count_ obs	a	b	num_ key	num_dates	char_val	char_ nonsense_ date	_ERROR_	_N_	Program step (PDV values taken before step)
6	0	1	5	.	Hello world	.	0	7	retain count_obs 0 ;
6	0	1	5	.	Hello world	.	0	7	merge src_a(in=a) src_b(in=b) ;
									count_obs = count_obs + 1 ;
									by num_key ;
									if a ;
									char_nonsense_date = input(put(num_dates,8.),yymmdd8.) ;
									output ;

- SAS loops again until it tries to read a new row of data from input files.
- Since SAS can not read any data in, it stops processing the current iteration.

… and now we’re done.

Control in the datastep

- Conditional processing and loops are huge strengths of the datastep.
- The basic datastep goes from top to bottom one line at a time.
- With loops and conditions, you can execute some statements more than once or not at all in specific iterations.

Control in the datastep

Instruction	Statement
Stop processing the current iteration	delete ;
Stop processing the current datastep	stop ;
Conditional processing	if - then - do
Looping	do, do while, do until
Go to specific portion of the datastep	go to statement

The datastep

VS

Proc SQL

Side by side

	Data step	Proc SQL
Joins	requires sorted/indexed input	No requirement* ✓
Unions	YES ✓	No interleave possible
Output	Multiple outputs ✓	Single output
Conditionnal processing	Strong with minimal code ✓	Strong but with a toll on the complexity
Aggregations	Manual and requires sorted input	No real limits ✓
Work usage	Minimal* ✓	Variable

Who wins?

- No one wins, it’s all about context.
- Learn to use both.
- Use Proc SQL to simplify programs by combining several different tasks in one when you are dealing with small to medium size datasets.
- Use the datastep for large dataset processing with conditional statements and loops.
- Besides, no one really wants to see a car mechanic fight an old lady!

References

- http://support.sas.com/documentation/cdl/en/lrcon/62955/HTML/default/viewer.htm#a000961108.htm
- http://support.sas.com/documentation/cdl/en/lrcon/68089/HTML/default/viewer.htm#p0e0mk25gs9binn1s9jiu4otau29.htm
- http://support.sas.com/documentation/cdl/en/lrcon/68089/HTML/default/viewer.htm#n1g8q3l1j2z1hjn1gj1hln0ci5gn.htm

What I couldn’t cover but wish I did!

- Using multiple « set » or « merge » statements in the datastep.
- Joining data with the use of formats and hash tables.
- Working on several rows of data (through retains or lag statements).
- Using arrays.
- Views to allow efficient chain datastep processing.

BONUS