ABSTRACT

In SAS V8, the SAS® Output Delivery System (ODS) in SAS/STAT greatly enhances the ability to manage statistical tables. In SAS 9.1, ODS Statistical Graphics enables SAS users to generate statistical graphics as easily as tables. This paper describes how to create statistical graphics automatically from the SAS/STAT procedures, as well as how to customize the layout and the appearance of statistical graphics using ODS templates and ODS styles.

INTRODUCTION

The SAS system continues to improve the graphics generated by SAS/STAT procedures. SAS/STAT procedures could only generate line printer plots before SAS Version 6.12. The plotting facility in the SAS/STAT procedures had been upgraded to high resolution plots since SAS Version 7. The high resolution graphics can be saved in graphics catalogs and controlled by the SAS/GRAPH GOPTIONS statement. The Product-Limit survival function estimate curves in Figure 1 were generated by the PROC LIFETEST procedure. Useful statistical information can be put into titles and footnotes by macro variables. You don’t have any control over the layout of the graphics area, such as legend for treatment group, y-axis label and tick marks. For information about how to generate the high resolution plots from PROC LIFETEST, refer to this author’s WUSS 10 paper (Cheng, 2002). If you really want to generate customized curves, you have to save analysis results in an output data set, display them with a SAS/GRAPH procedure and use the Annotate facility.

Figure 1

Product-Limit Survival Curve Generated by SAS V8.2 (N=40)
Median Survival of Placebo is 256.0 Days (N=20)
Median Survival of Drug X is 235.5 Days (N=20)

P value from Log-Rank Test: 0.0175
SOURCE: WUSS12_SAMPLE.SAS WCHENG SASv8.2 {30JUL2004 17:39}
In SAS 9, a number of SAS/STAT procedures can use the ODS to create statistical graphics automatically. The new facility is referred to as ODS Statistical Graphics (or ODS Graphics for short). The layout and appearance of ODS Graphics are controlled by ODS templates and styles. You can use PROC TEMPLATE to create your statistical graphics templates and generate statistical graphics from DATA step, or you can use PROC TEMPLATE to customize the statistical graphics generated by SAS/STAT procedures. Unlike the high resolution plots in SAS Version 8, in SAS 9 you can control every part on the graphics area.

In this paper, PROC LIFETEST will be used as an example to demonstrate how to generate graphics using ODS Graphics, and how to customize graphics using the TEMPLATE procedure. The programs can be adapted to other SAS/STAT procedures which support ODS Graphics with the same principle.

GENERATING STATISTICAL GRAPHICS

The ODS GRAPHICS statement is specified to request ODS Graphics in addition to the tabular output:

Example 1

```
ods graphics on / reset imagename = "wussgraph" imagefmt = png ;
ods html  path  = "C:\wuss2004" gpath = "C:\wuss2004\graph" (url = "graph/"
file  = "wuss.html" style = statistical;

proc lifetest data = exposed;
   time days * status(0);
   strata treatment;
run;

ods html close;
ods graphics off;
```

The data set EXPOSED is taken from the "Getting Started" section of Chapter 40, "The LIFETEST Procedure", in the SAS OnlineDoc 9.1. Figure 2 displays the graph of the product-limit survival function estimate versus survival time, as well as the summary statistics, generated from the preceding program:

![Product-Limit Survival Function Estimates](image)

**Figure 2**

<table>
<thead>
<tr>
<th>Drug X</th>
<th>20</th>
<th>90% (18)</th>
<th>10% (2)</th>
<th>255.0 (255.0)</th>
<th>319.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placebo</td>
<td>20</td>
<td>90% (18)</td>
<td>10% (2)</td>
<td>235.6 (289.0)</td>
<td>263.6</td>
</tr>
</tbody>
</table>
If you want to view the other graphical displays of the survival distribution and related function estimates that PROC LIFETEST can produce, you can specify the PLOTS = option in the SURVIVAL statement:

Example 2

```sql
ods graphics on / reset imagename = "wussgraph" imagefmt = png ;
ods html path = "C:\wuss2004" gpath = "C:\wuss2004\graph" (url = "graph/"
file = "wuss.html" style = statistical;
proc lifetest data = exposed;
time days * status(0);
strata treatment;
survival plots = ( survival, density, epb, hazard, logsurv
, hwb, cl, stratum)
confband = all;
run;
ods html close;
ods graphics off;
```

Figure 3 to 9 are other statistical graphics generated by the preceding program, and include a panel of plots for each stratum, a plot of the survival functions estimates for all strata, a plot of the Hall-Wellner bands for all strata, a plot of the equal precision bands for all strata, a plot of negative log of the estimated survival functions, and a plot of the log of the negative log of the estimated survival functions:

![Figure 3](image)

![Figure 4](image)

![Figure 5](image)

![Figure 6](image)
Statistical graphics are controlled by graph templates, which are written in the graph template language. The default graph templates supplied by SAS should suffice in most common cases of SAS procedures. However, ODS Graphics enables you to modify the default template to customize the graphics when modifications are needed.


**SWAPPING THE LOCATIONS OF FREQUENCY AND PERCENTAGE**

In the summary statistics displayed with the Product-Limit survival function estimates curve in Figure 2, the frequency of Event and Censored are displayed inside parentheses. If you want to swap the locations of frequency and percentage, and display the percentage inside parentheses, you can modify the portion which specifies the summary statistics in the template:

### Example 3

```plaintext
ods path work.mytmpl(update) sashelp.tmplmst(read);
proc template;
```

---

CUSTOMIZING LAYOUT OF ODS GRAPHICS

**Figure 7**

95% Equal Precision Confidence Bands for Survivorship

**Figure 8**

Negative Log of Estimated Survivor Functions

**Figure 9**

Log of Negative Log of Estimated Survivor Functions

[SNIP]
layout gridded / rows=1 halign=left;
  entry NEVENT1 / padleft=0 padright=0;
  entry " (" / padleft=0 padright=0;
  entry PCTEVENT1 / format=2.0 halign=right padright=0;
  entry ")" / padleft=0;
endlayout;

layout gridded / rows=1 halign=left;
  entry NCENSORED1 / padleft=0 padright=0 format = 3.0;
  entry " (" / padleft=0 padright=0;
  entry PCTCENSORED1 / format=2.0 halign=right padright=0;
  entry ")" / padleft=0;
endlayout;

[SNIP]
entry NOBS2;
layout gridded / rows=1 halign=left;
  entry NEVENT2 / padleft=0 padright=0;
  entry " (" / padleft=0 padright=0;
  entry PCTEVENT2 / format=2.0 halign=right padright=0;
  entry ")" / padleft=0;
endlayout;

layout gridded / rows=1 halign=left;
  entry NCENSORED2 / padleft=0 padright=0 format = 3.0;
  entry " (" / padleft=0 padright=0;
  entry PCTCENSORED2 / format=2.0 halign=right padright=0;
  entry ")" / padleft=0;
endlayout;

end;
[SNIP]
run;

The resulting Product-Limit survival function estimates, after submitting the preceding program and Example 1, is shown in Figure 10:

**Figure 10**

![Product-Limit Survival Function Estimates](image-url)
SWAPPING THE LOCATIONS OF LEGEND FOR P-VALUE AND TREATMENT GROUP

This example is a continuation of Example 3. The objective is to swap the locations of the legend which specify p-value and treatment group. In the “Product-Limit Survival” template definition, the options HALIGN and VALIGN specify the horizontal and vertical alignment of the legend:

Example 4

```
proc template;
        [SNIP]
        DiscreteLegend "Survival" / halign=left valign=bottom across=1 border=true;
        layout gridded / rows=1 halign=right valign=top border=true;
        [SNIP]
    end;
run;
```

To display the modifications, shown in Figure 11, submit the modified template definition and then resubmit the program in Example 1.

Figure 11

![Product-Limit Survival Function Estimates](image)

CHANGING TICK MARKS AND LABEL OF Y-AXIS

Sometimes you don’t like the default label “Survival Probability” of the y-axis and the default tick marks on the y-axis which are 0, 0.2, 0.4, 0.6, 0.8, and 1. This example, which is a continuation of Example 5, illustrates how to change the tick marks and the label of y-axis:

Example 5

```
proc template;
        [SNIP]
        layout overlay / yaxisopts=( label="My Label for Y Axis" ticks=( 0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 ) );
        [SNIP]
```
The resulting Product-Limit survival curve, after submitting the preceding statements and the statements in Example 1, is shown in Figure 12:

![Figure 12](image)

**Figure 12**

**CHANGING THE SYMBOL VALUE FOR THE CENSORED OBSERVATIONS**

This example, which is a continuation of Examples 3 - 5, illustrates how to change the symbol value for the censored observations.

You can use the `MARKERSYMBOL=` option to specify the symbol value to mark the censored observations. By default, the symbol is a “+” sign. You can change the symbol to an asterisk (*):

**Example 6**

```plaintext
proc template;
[SNIP]
    layout overlay / yaxisopts=( label="My Label for Y Axis" 
        ticks=( 0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 ) );
    stepplot y=SURVIVAL x=TIME / group=STRATUM index=STRATUMNUM name="Survival";
    scatter y=CENSORED x=TIME / group=STRATUM
        index=STRATUMNUM
        markersymbol=star
        markersize=StatGraphData:markersize;
[SNIP]
end;
run;
```

The result of the change, after submitting the modified template definition and the program in Example 1, is displayed in Figure 13:

![Figure 13](image)

**Figure 13**

- **Drug X**
  - No. of Subjects: 20
  - Event: 18 (90%)
  - Censored: 2 (10%)
  - Median Survival: 250.0 (95% CL: 255.0, 319.0)

- **Placebo**
  - No. of Subjects: 20
  - Event: 18 (90%)
  - Censored: 2 (10%)
  - Median Survival: 235.6 (95% CL: 209.0, 263.0)
ADDING GRID LINES TO Y-AXIS

The last example of modifications to the Stat.Lifetest.Graphics.ProductLimit template illustrates how to add grid lines to the y-axis. It is a continuation of Example 6.

You can add the grid lines by specifying `YGRID = TRUE`, and the degree of transparency by specifying `GRIDTRANSPARENCY = 0.5` as half transparent:

**Example 7**

```plaintext
proc template;
  [SNIP]
  layout overlay / yaxisopts=( label="My Label for Y Axis"
   ticks=( 0 .1 .2 .3 .4 .5 .6 .7 .8 .9 1.0 )
   ygrid = 1
   gridtransparency = 0.5);
  stepplot y=SURVIVAL x=TIME / group=STRATUM
    index=STRATUMNUM
    name="Survival";
  scatter y=CENSORED x=TIME / group=STRATUM
    index=STRATUMNUM
    markersymbol=star
    markersize=StatGraphData:markersize;
  [SNIP]
end;
run;
```

The result of these modifications, after submitting the modified template definition and the program in Example 1, is displayed in Figure 14.
MODIFYING PANELS

The next example illustrates how to modify the panel of plots for each stratum in Figure 3 and Figure 4. The original panel consists of three plots and a summary statistics text box. The template that defines the original panel is “Stat.Lifetest.Graphics.ProductLimitPanel”. In Example 8, the panel is modified so that it includes only the Product-Limit survival curve and the summary statistics with 25 and 75 percentile statistics removed. The ROWS=1 and COLUMNS=2 options in the LAYOUT LATTICE statement specify a 1 x 2 lattice. The LAYOUT statements for components 3 and 4, percentiles 25 and 75 are deleted.

Example 8

``` SAS 
proc template;
    [SNIP]
    layout lattice / rows=1
    columns=2
      vrange=unionall
      hrange=unionall;
    rowaxes;
      axiscomp display=( ticks values label )
      label="Survival" ticks=0
    [SNIP]
    entry "50";
      layout gridded / rows=1
        halign=left;
    [SNIP]
  end;
run;
```

After submitting the modified template definition and the program in Example 2, you can get a simplified panel, which is shown in Figure 15 and Figure 16.
If you have modified a style to customize the appearance of ODS tables, you can modify a style to customize the appearance of ODS Graphics in the same way. Example 9 shows how to enlarge the fonts for the axis value (tick mark) labels and axis labels if you want to emphasize them in the graph.

**Example 9**

```sas
ods path work.mytmpl(update)
    sashelp.tmplmst(read);

proc template;
    define style mystyle;
        parent = styles.statistical;
        replace GraphFonts /
            'GraphDataFont' = "Arial",8pt
            'GraphFootnoteFont' = "Arial",8pt,Bold
            'GraphTitleFont' = "Arial",8pt,Bold
            'GraphValueFont' = "Arial",16pt,Bold
            'GraphLabelFont' = "Arial",18pt,Bold;
    end;
run;
ods graphics on / reset imagename = "wussgraph" imagefmt = png ;

ods html path = "C:\WUSS2004"
gpath = "C:\WUSS2004\graph" (url = "graph/")
    file = "WUSS.html"
        style = mystyle;

proc lifetest data = exposed;
    time days * status(0);
    strata treatment;
run;
ods html close;
ods graphics off;
```
Submit the preceding program to display the Product-Limit survival curve created with your modified style, as shown in Figure 17:

**Figure 17**

CONCLUSION

ODS Statistical Graphics is an exciting new facility provided by SAS 9. It integrates the graphic display with the tabular output. It automates the production of statistical graphics which become more and more important in modern statistical analysis, while maintaining the ability to customize the displays by modifying the ODS templates and ODS styles.

REFERENCES


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