



# Next-generation Graphics

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**PhUSE Single Day Event: Transforming Data Visualization– A Peek into the Future of Clinical Data Analysis Description**

# Next-generation Graphics Overview

- The need for a “new generation” of graphics
- The solution that was right in front of us  
(spoiler alert— it is SAS<sup>®</sup>)!
- A peek behind the curtain: “Next-generation graphics”

# The Need for a New Generation of Graphics: Increased Demand

- Traditional- CSR/Regulatory filing
- Publication
- Drug safety monitoring
- Data exploration



# The Need for a New Generation of Graphics: Legacy System Challenges

- SAS 9.1.3 PROC GPLOT / GCHART
- Legacy system of macros- powerful but complex
  - Difficult to understand/maintain
  - Large user document– 40 pages!



# The Need for a New Generation of Graphics: Legacy System Challenges (continued)

- Legacy system
  - ~20 sub-macros
  - ~100 scheme datasets
    - Area scheme, Line scheme, Symbol scheme
- ~170 parameters
- Tremendous 2000 ~ 5000 lines of code for flexibility and functionality

# The Need for a New Generation of Graphics: Unmet Needs

- Simplified code for users, developers, customers



- Additional capabilities (e.g. interactive plots)

- Simplified user documentation



# The Need for a New Generation of Graphics: New Tools/Capabilities!



- Spotfire, R, R-Shiny, Python- more recent tools
- Improved graphics capabilities in SAS 9.2/9.3
- SAS is being used for Next Generation Graphs:
  - Widely accepted for regulatory submissions
  - Seamless utilization of legacy datasets
  - Familiar product
  - Vastly improved capabilities and ease of use
  - SAS 9.3 ODS Graphics Designer- interactive

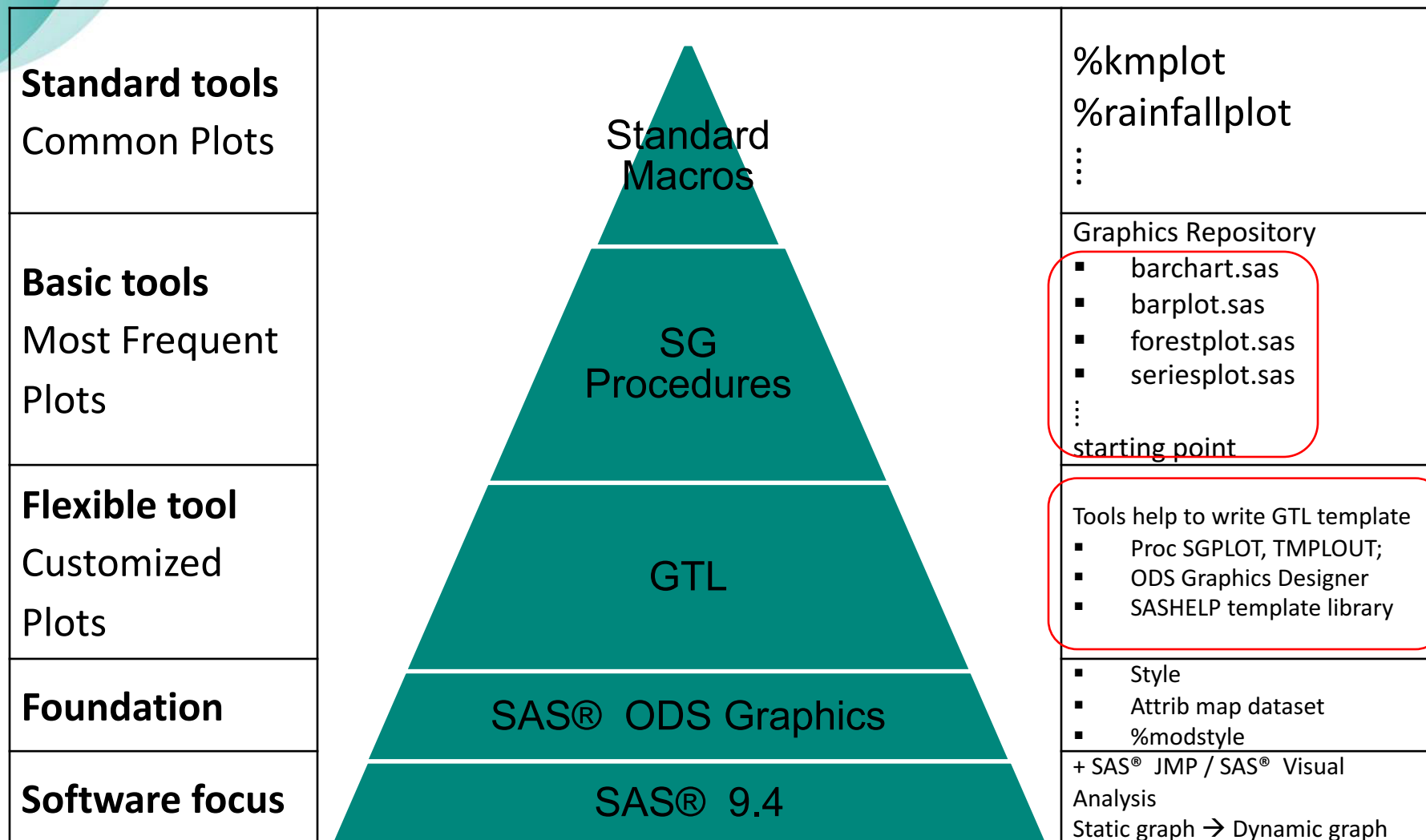
# The Need for a New Generation of Graphics: ODS Graphic Tools

| Traditional SAS GRAPH <sup>1</sup>                                                       | ODS Graphics                                                                |
|------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| Graphs are device-based                                                                  | Graphs are template-based                                                   |
| Produces GRSEG entries in SAS graphics catalogs that can be rendered in standard formats | Produces graphs in standard formats such as JPEG and PNG                    |
| Graphs are viewed in the Graph window                                                    | Graphs are viewed in standard viewers such as a web browser for HTML output |
| Can use GOPTIONS statements to control appearance of graphs                              | Can use ODS GRAPHICS statements to control appearance of graphs             |
| Graphs are not produced automatically                                                    | Statistical procedures produce graphs automatically                         |

<sup>1</sup>Graphing Made Easy with SGPLOT and SGPANEL Procedures Susan J. Slaughter, Avocet Solutions, Davis, CA Lora D. Delwiche, University of California, Davis, CA. SAS Global Forum 15 Proceedings. Paper 2441-2015

# A Peek behind the Curtain

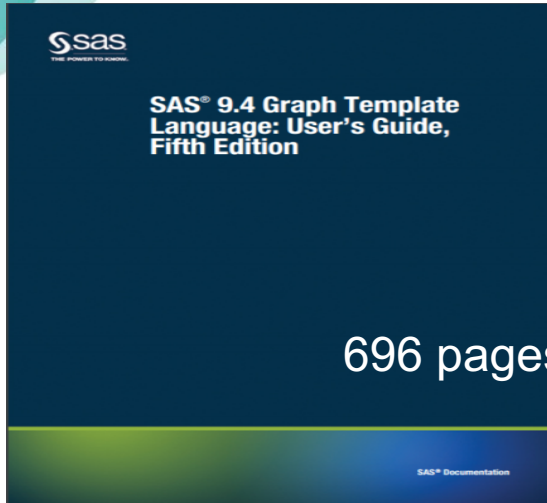
## Next-generation Graphics: Re-building with SAS!



# Next Generation Graphics: Graphic Repository Features

- **SAS 9.4, ODS**
- SG Procedures:
  - SGPLOT      SGPANEL      SGSCATTER
- Graph Template Language (GTL)
- Default/Customized Styles
- Attribute-map
- SAS built-in macros
- Simple templates
- Concise, yet effective, user documentation

# Next Generation Graphics: SAS tools helping to develop GTL code



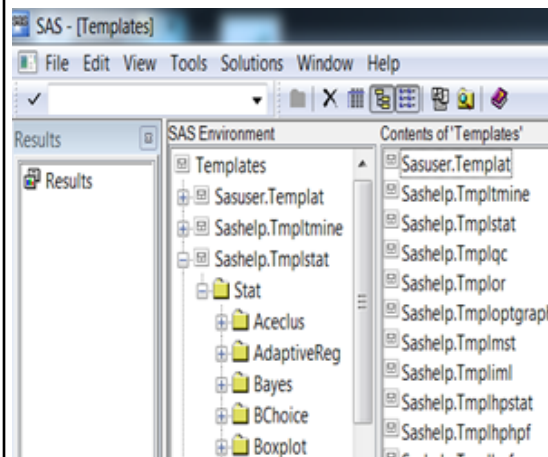
- Different from traditional coding



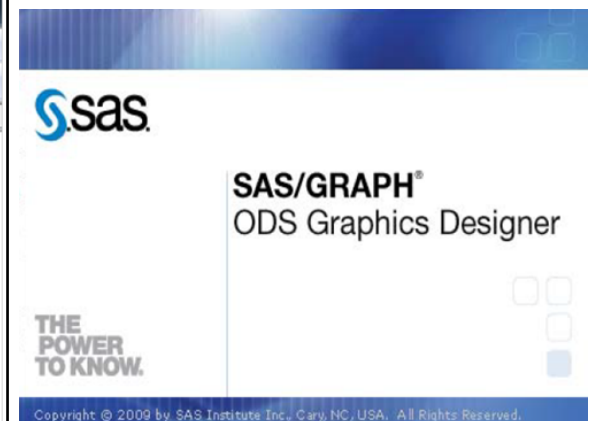
## TMPLOUT Option

```
proc sgplot data=sashelp.classfit
  tmpout="&wkdir\my_tmp.sas";
scatter x=height y=weight
        / group=sex datalabel=name;
axis grid;
yaxis grid;
run;
```

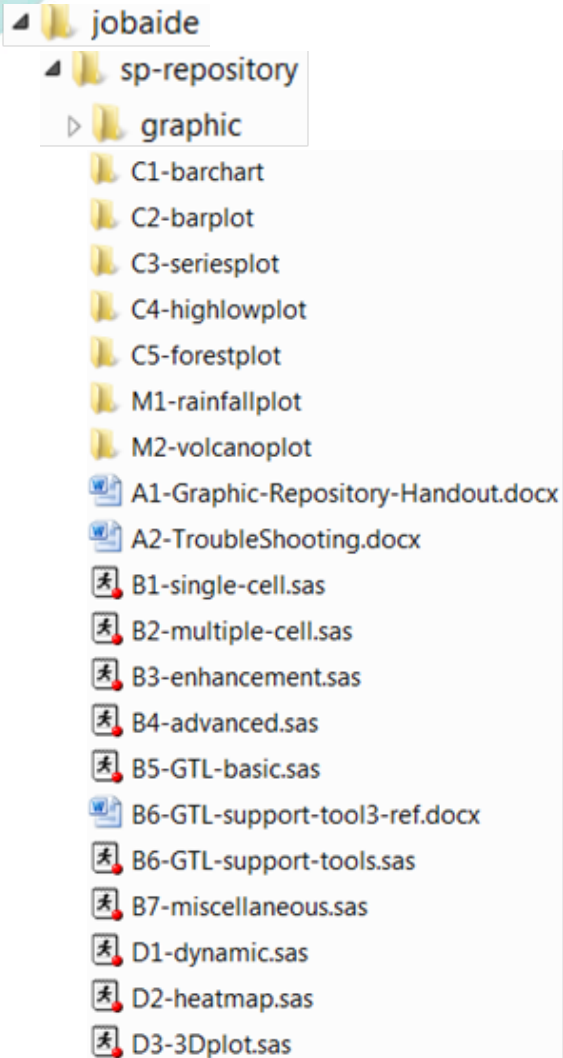
## Template Library



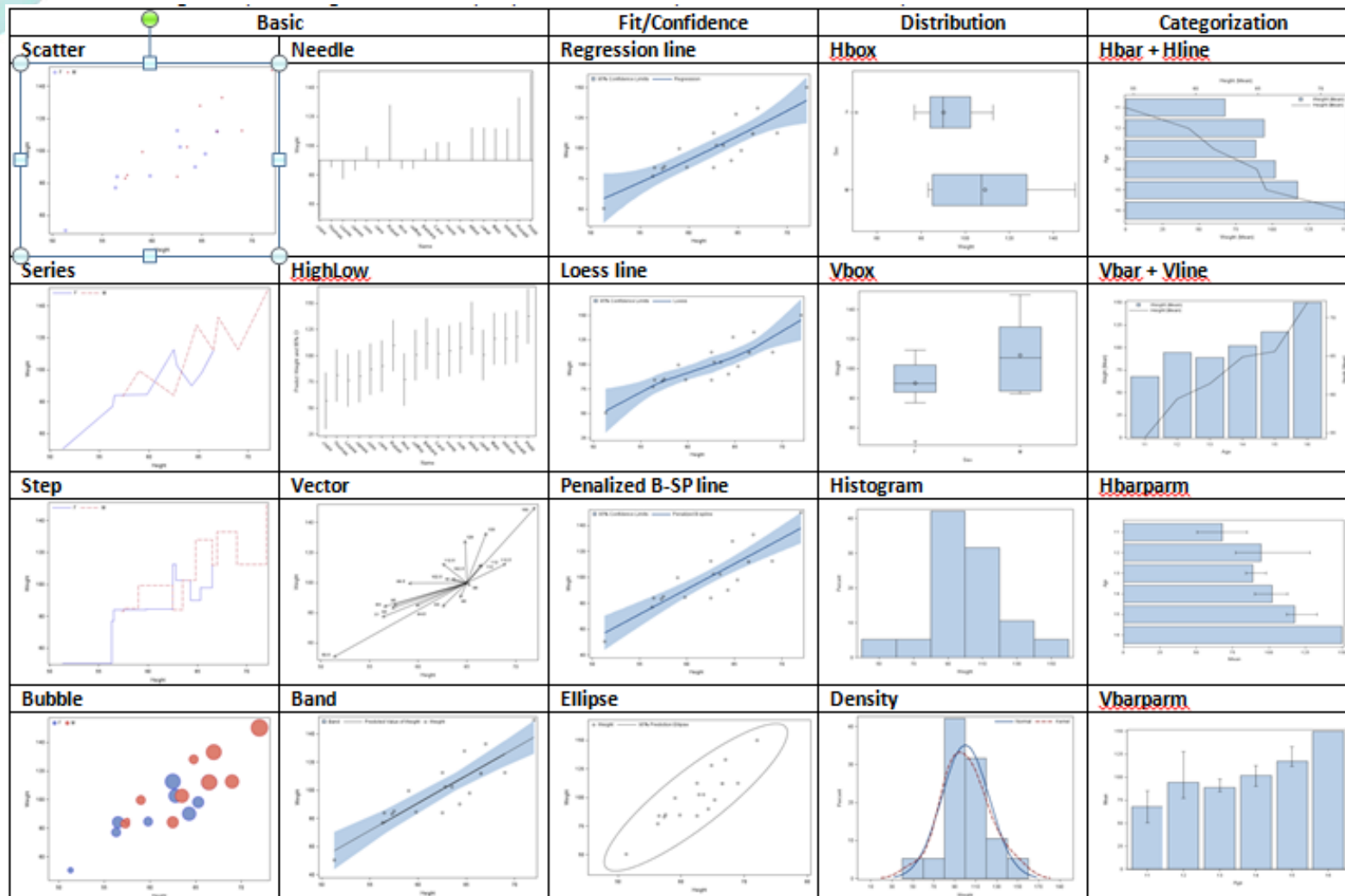
## SAS® ODS Graphic Designer



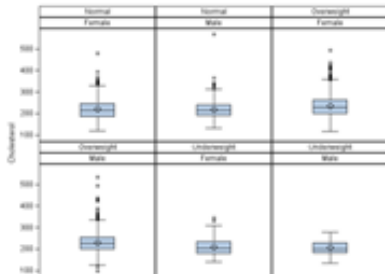
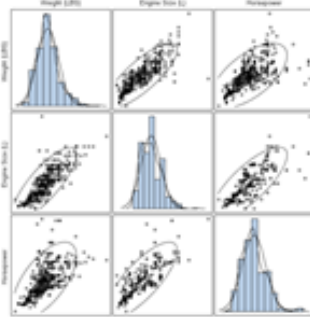
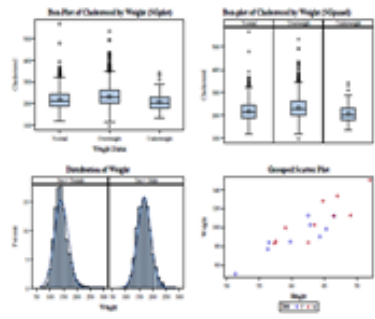
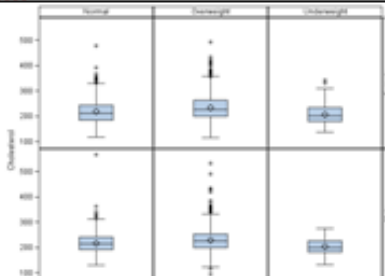
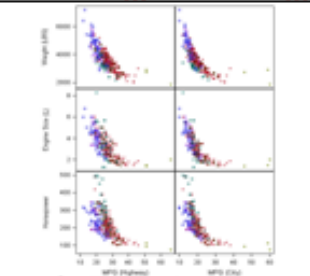
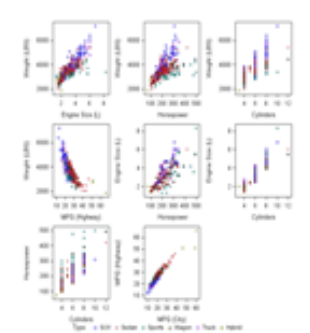
# Next Generation Graphics: Structure & Function

|                                                                                                                            |                                                                                            |                                                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><u>\\bardsar-prod\standards\</u></p>  | <p><b>A-docx files</b><br/>User document</p>                                               | <ul style="list-style-type: none"> <li>• Tool Index</li> <li>• Troubleshooting</li> <li>• Updates</li> </ul>                                                                                |
|                                                                                                                            | <p><b>B-SAS files</b><br/>Basic knowledge of ODS Graphics using SAS 9.4</p>                | <ul style="list-style-type: none"> <li>• Simple plots</li> <li>• Learning material</li> </ul>                                                                                               |
|                                                                                                                            | <p><b>C-folders</b><br/>SAS template code with examples</p>                                | <ul style="list-style-type: none"> <li>• Custom plots</li> <li>• Legacy system graphs</li> <li>• Title/Note location</li> </ul>                                                             |
|                                                                                                                            | <p><b>M-folders</b><br/>Updated/newly developed macro. Not yet fully validated per SOP</p> | <ul style="list-style-type: none"> <li>• For common plots</li> <li>• %rainfallplot</li> <li>• %volcanoplot</li> <li>• Updates underway</li> </ul>                                           |
|                                                                                                                            | <p><b>D-SAS files</b><br/>Plots under development</p>                                      | <p>Will be reclassified into categories B, C or M after completion.</p> <ul style="list-style-type: none"> <li>• dynamic additional info.</li> <li>• heatmap</li> <li>• 3D plots</li> </ul> |

# Next Generation Graphics Example: B1-single-cell.sas- SGPLOT single-cell plots



# Next Generation Graphics: B2-multiple-cell.sas SGPANEL, SGSCATTER, ODS LAYOUT

| PROC SGPANEL                                                                                                                          | PROC SGSCATTER                                                                                                                             | ODS LAYOUT statement (pdf file)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><u>Panelby ... / Layout = panel</u></p>           | <p><u>Matrix V1 V2 ... Vn</u></p>                        | <p><u>ods layout start columns=n rows=m;</u></p>                                                                                                                                                                                                                                                                                                                                                                                          |
| <p><u>Panelby ... / Layout = lattice</u></p>         | <p><u>Compare Y=(Y1 Y2 ... Yn) X=(X1 X2 ... Xm)</u></p>  | <p><u>ods pdf file="&amp;dir\filenm.pdf" startpage=never;</u><br/><u>ods layout start columns=2 rows=3;</u><br/><u>ods region column=1 row=1;</u><br/>SAS code for plot 1;<br/><u>ods region column=1 row=2;</u><br/>SAS code for plot 2;<br/><u>ods region column=1 row=3;</u><br/>SAS code for plot 3;<br/><u>ods region column=2 row=1;</u><br/>SAS code for plot 4;<br/><u>ods region column=2 row=2;</u><br/>SAS code for plot 5;<br/><u>ods layout end;</u><br/><u>ods pdf file="&amp;wkdir\filenm.pdf" close;</u></p> |
| <p><u>Panelby ... / Layout = columnlattice</u></p>  | <p><u>Plot Y1*X1 Y2*X2 ... Yn*Xm</u></p>                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |

# Next Generation Graphics: Foundation of SG-Procedures

| Abstract Framework                                                                                                                                                                                                                                                                                                                                                                            | GTL Key components                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|------------------------------------|--------------------|----------------------------------|------------------|------------------|--------------------|--------------------|--------------------|-------------------------------------|--------------------|-----------------------------------|---------------------|--------------------------------------|------------------|------------------------------------|-------------------|-----------------------|------------------------|-----------------------------------------|----------------------|---------------------------------------|---------|--|
| <pre>proc template;   <b>define statgraph</b> <i>tpl_name</i>;     <b>begingraph</b>;       entrytitle "<i>title text</i>";       entryfootnote '<i>foot text</i>';       <b>layout</b> <i>layout_type</i> ;         plot-statement...;         discretelegend...;       <b>endlayout</b>;     <b>endgraph</b>;   <b>end</b>; run;</pre> <pre>proc sgrender data=... template=...; run;</pre> | <p><b>2-step process</b><br/>proc template (define)<br/>proc sgrender (create)</p> <p><b>3 blocks</b><br/>define – end<br/>begingraph – endgraph<br/>layout – endlayout</p> <p><b>4 Key components</b><br/>Layout<br/>Plot<br/>EntryTitle/EntryFootnote/Entry<br/>DiscreteLegend/MergedLegend</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| Layout Summary                                                                                                                                                                                                                                                                                                                                                                                | Plot Statement Summary                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| <p><b>Single-cell</b><br/>Layout OVERLAY</p> <p><b>Classification Panels</b><br/>Layout DATAPANEL<br/>Layout DATALATTICE<br/>layout PROTOTYPE</p> <p><b>Multiple-cell</b><br/>Layout LATTICE<br/>Layout GRIDDED</p>                                                                                                                                                                           | <table> <tr> <td>SCATTER<b>PLOT</b></td><td><b>BoxPlot / orient=horizontal</b></td></tr> <tr> <td>SERIES<b>PLOT</b></td><td><b>BoxPlot / orient=vertical</b></td></tr> <tr> <td>STEP<b>PLOT</b></td><td><b>HISTOGRAM</b></td></tr> <tr> <td>BUBBLE<b>PLOT</b></td><td><b>DENSITYPLOT</b></td></tr> <tr> <td>NEEDLE<b>PLOT</b></td><td><b>BarChart / orient=horizontal</b></td></tr> <tr> <td>VECTOR<b>PLOT</b></td><td><b>BarChart / orient=vertical</b></td></tr> <tr> <td>HIGHLOW<b>PLOT</b></td><td><b>LineChart / orient=horizontal</b></td></tr> <tr> <td>BAND<b>PLOT</b></td><td><b>LineChart / orient=vertical</b></td></tr> <tr> <td>LOESS<b>PLOT</b></td><td><b>WATERFALLCHART</b></td></tr> <tr> <td>REGRESSION<b>PLOT</b></td><td><b>BarChartParm / orient=horizontal</b></td></tr> <tr> <td>PBSPLINE<b>PLOT</b></td><td><b>BarChartParm / orient=vertical</b></td></tr> <tr> <td>ELLIPSE</td><td></td></tr> </table> | SCATTER <b>PLOT</b> | <b>BoxPlot / orient=horizontal</b> | SERIES <b>PLOT</b> | <b>BoxPlot / orient=vertical</b> | STEP <b>PLOT</b> | <b>HISTOGRAM</b> | BUBBLE <b>PLOT</b> | <b>DENSITYPLOT</b> | NEEDLE <b>PLOT</b> | <b>BarChart / orient=horizontal</b> | VECTOR <b>PLOT</b> | <b>BarChart / orient=vertical</b> | HIGHLOW <b>PLOT</b> | <b>LineChart / orient=horizontal</b> | BAND <b>PLOT</b> | <b>LineChart / orient=vertical</b> | LOESS <b>PLOT</b> | <b>WATERFALLCHART</b> | REGRESSION <b>PLOT</b> | <b>BarChartParm / orient=horizontal</b> | PBSPLINE <b>PLOT</b> | <b>BarChartParm / orient=vertical</b> | ELLIPSE |  |
| SCATTER <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                           | <b>BoxPlot / orient=horizontal</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| SERIES <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                            | <b>BoxPlot / orient=vertical</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| STEP <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                              | <b>HISTOGRAM</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| BUBBLE <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                            | <b>DENSITYPLOT</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| NEEDLE <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                            | <b>BarChart / orient=horizontal</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| VECTOR <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                            | <b>BarChart / orient=vertical</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| HIGHLOW <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                           | <b>LineChart / orient=horizontal</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| BAND <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                              | <b>LineChart / orient=vertical</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| LOESS <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                             | <b>WATERFALLCHART</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| REGRESSION <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                        | <b>BarChartParm / orient=horizontal</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| PBSPLINE <b>PLOT</b>                                                                                                                                                                                                                                                                                                                                                                          | <b>BarChartParm / orient=vertical</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |
| ELLIPSE                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                     |                                    |                    |                                  |                  |                  |                    |                    |                    |                                     |                    |                                   |                     |                                      |                  |                                    |                   |                       |                        |                                         |                      |                                       |         |  |

# Next Generation Graphics: Foundation of SG-Procedures- Template

```
proc template;  
  define statgraph tmpl_name;  
    begingraph;  
      entrytitle "title text";  
      entryfootnote 'foot text';  
      layout layout_type ;  
      plot-statement...;  
      discretelegend...;  
    endlayout;  
  endgraph;  
end;  
  
run;  
proc sgrender data=... template=...;  
run;
```

# Next Generation Graphics: Foundation of SG-Procedures- Layout

- Layout Summary
  - **Single-cell**
  - Layout OVERLAY
- **Classification Panels**
  - Layout DATAPANEL
  - Layout DATALATTICE
  - layout PROTOTYPE
- **Multiple-cell**
  - Layout LATTICE
  - Layout GRIDDED

# Next Generation Graphics: Foundation of SG-Procedures- Key Components

- **2-step process**
  - proc template (define)
  - proc sgrender (create)
- **3 blocks**
  - define – end
  - begingraph – endgraph
  - layout – endlayout
- **4 Key components**
  - Layout
  - Plot
  - EntryTitle/EntryFootnote/Entry
  - DiscreteLegend/MergedLegend

# Next Generation Graphics: Foundation of SG-Procedures- Plot Statement

- **SCATTERPLOT**                      **BoxPlot / orient=horizontal**
- **SERIESPLOT**                      **BoxPlot / orient=vertical**
- **STEPLOT**                      **HISTOGRAM**
- **BUBBLEPLOT**                      **DENSITYPLOT**
- **NEEDLEPLOT**                      **BarChart / orient=horizontal**
- **VECTORPLOT**                      **BarChart / orient=vertical**
- **HIGHLOWPLOT**                      **LineChart / orient=horizontal**
- **BANDPLOT**                      **LineChart / orient=vertical**
- **LOESSPLOT**                      **WATERFALLCHART**
- **REGRESSIONPLOT**                      **BarChartParm / orient=horizontal**
- **PBSPLINEPLOT**                      **BarChartParm / orient=vertical**
- **ELLIPSE**

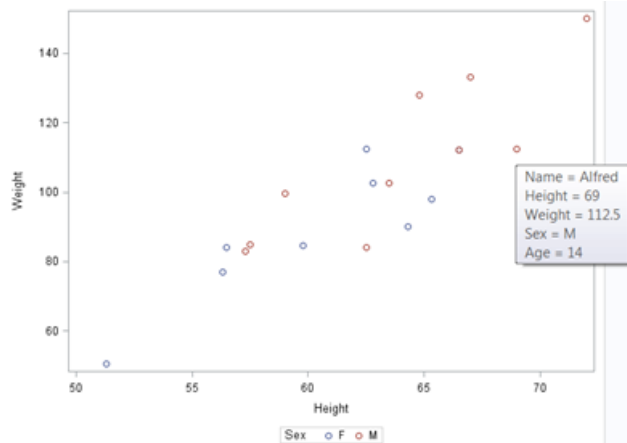
# Next Generation Graphics:

## Useful SAS built-in/provided macros

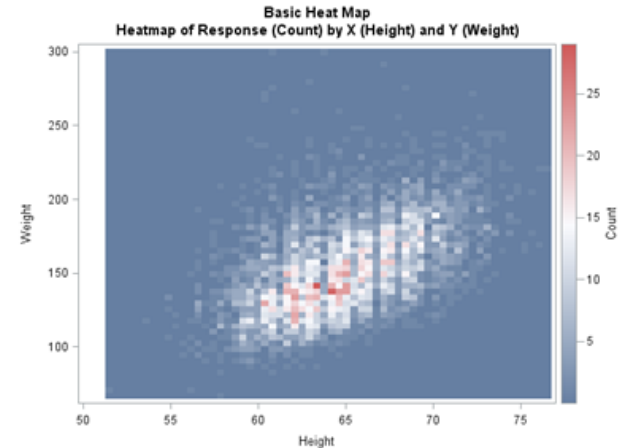
| Color                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Annotate                                                                                                                                                                                                                                                                                                                                                                                         | %ProvideSurvivalMacros                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>* To initiate color utility macros;<br/><b>%colormac</b>;</p> <p>* To get help;<br/><b>%helpclr</b>;      * list all macros;<br/><b>%helpclr(all)</b>;    * info of all macros;<br/><b>%helpclr(rgb)</b>;   * info of macro rgb;</p> <p>* example using %rgb as palette.;<br/><b>%colormac</b>;</p> <p><b>proc sgplot</b> data=sashelp.class ;<br/>    scatter x=height y=weight /<br/>    markerattrs=(symbol=squarefilled<br/>    color=%<b>rgb(100,0,0)</b> size=<b>11</b>);<br/><b>run</b>;</p> | <p>* To initiate annotation macros;<br/><b>%sganno</b>;</p> <p>* To get help;<br/><b>%sganno_help</b>;<br/><b>%sganno_help(all)</b>;<br/><b>%sganno_help(sgtext)</b>;</p> <p><b>%SGTEXT</b><br/><b>%SGLINE</b><br/><b>%SGARROW</b><br/><b>%SGOVAL</b><br/><b>%SGRECTANGLE</b><br/><b>%SGPOLYGON</b><br/><b>%SGPOLYLINE</b><br/><b>%SGPOLYCONT</b><br/><b>%SGTEXTCONT</b><br/><b>%SGIMAGE</b></p> | <p><b>%ProvideSurvivalMacros</b>;<br/>%let yOptions =<br/>label="Survival"<br/>linearopts=(<br/>viewmin=0<br/>viewmax=1<br/>tickvaluelist=(0 .1 .2 .3 .4 .5 .6 .7 .8 .9<br/>1)<br/>);<br/><b>%CompileSurvivalTemplates</b>;</p> <p><b>proc lifetest</b> data=sashelp.BMT plots =<br/>survival (atrisk=<b>0</b> to <b>2500</b> by <b>500</b>);<br/>    time T * Status (<b>0</b>);<br/>    strata group<br/>    / test=logrank adjust=sidak;<br/><b>run</b>;</p> |

# Next-Generation Graphics: Plots in Development

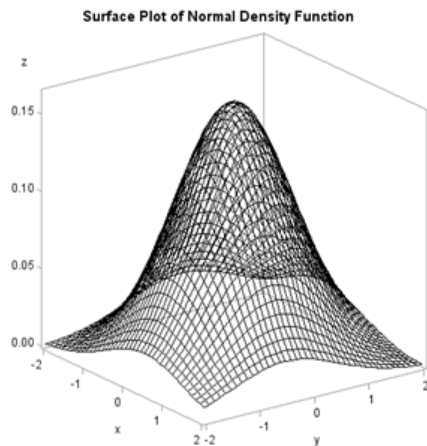
D1-dynamic.sas



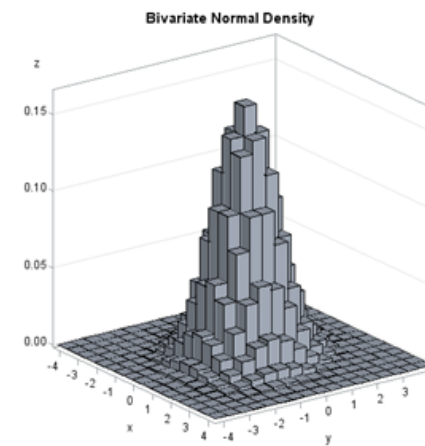
D2-heatmap.sas



D3-3Dplot.sas (surface plot)



D3-3Dplot.sas (3D histogram plot)



# Next-Generation Graphics:

*Where We Are?*

| Legacy Macros                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Graphic Repository                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Graphics<br>Next<br>Generation |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------|
| <p><b>SAS® 9.1.3 or before</b><br/><b>SAS/GRAPH</b></p> <ul style="list-style-type: none"> <li>▪ PROC GPLOT / GCHART</li> <li>▪ Isolated huge SAS® macros</li> <li>▪ ~20 sub-macros</li> <li>▪ ~100 scheme dataset                             <ul style="list-style-type: none"> <li>○ Area scheme</li> <li>○ Line scheme</li> <li>○ Symbol scheme</li> </ul> </li> <li>▪ ~170 parameters</li> <li>▪ Tremendous lines of code                             <ul style="list-style-type: none"> <li>○ 2000 ~ 5000 lines</li> </ul> </li> <li>▪ Large user document                             <ul style="list-style-type: none"> <li>○ ~40 pages</li> </ul> </li> </ul> | <p><b>SAS® 9.4</b><br/><b>ODS Graphics</b></p> <ul style="list-style-type: none"> <li>▪ SG Procedures                             <ul style="list-style-type: none"> <li>○ SGPLOT</li> <li>○ SGPANEL</li> <li>○ SGSCATTER</li> </ul> </li> <li>▪ GTL</li> <li>▪ Default/Customized Styles</li> <li>▪ Attribute-map</li> <li>▪ SAS® build-in macros                             <ul style="list-style-type: none"> <li>○ %modstyle ...</li> </ul> </li> <li>▪ Simple template</li> <li>▪ Short user document</li> </ul> |                                |
| <p>-Code is outdated<br/>-Too complex<br/>-Hard to understand/maintain</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <p>-Introducing<br/>-To obtain proof of concept<br/>-Preparing and Implementing</p>                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                |

# Next Generation Graphics: Related Reference Links

SAS® 9.4 ODS Graphics: Procedures Guide

<http://support.sas.com/documentation/cdl/en/grstatproc/69716/HTML/default/viewer.htm#titlepage.htm>

SAS® 9.4 Graph Template Language: User's Guide

<http://support.sas.com/documentation/cdl/en/grstatug/69747/PDF/default/grstatug.pdf>

SAS® 9.4 Graph Template Language: Reference

<http://support.sas.com/documentation/cdl/en/grstatgraph/69718/HTML/default/viewer.htm#titlepage.htm>

SAS® 9.4 ODS Graphics Designer: User's Guide

<https://support.sas.com/documentation/cdl/en/grstatdesignug/68403/PDF/default/grstatdesignug.pdf>

Clinical Graphs Using SAS®

[https://www.sas.com/storefront/aux/en/spclinicalgraphs/68179\\_toc.pdf](https://www.sas.com/storefront/aux/en/spclinicalgraphs/68179_toc.pdf)

Statistical Graphics Procedures by Example

[https://www.sas.com/store/books/categories/examples/statistical-graphics-procedures-by-example-effective-graphs-using-sas-/prodBK\\_63855\\_en.html](https://www.sas.com/store/books/categories/examples/statistical-graphics-procedures-by-example-effective-graphs-using-sas-/prodBK_63855_en.html)

Paper 2441-2015 Graphing Made Easy with SGPLOT and SGPANEL Procedures Susan J. Slaughter, Avocet Solutions, Davis, CA Lora D. Delwiche, University of California, Davis, CA

<https://support.sas.com/resources/papers/proceedings15/2441-2015.pdf>

A decorative graphic in the top-left corner consisting of several overlapping teal circles of varying shades, creating a modern, abstract look.

# Next-Generation Graphics

- Contact information:  
shuping\_zhang@merck.com  
susan.kramlik@merck.com



Thank You!



- 
- A decorative graphic in the top-left corner consisting of several overlapping teal-colored circles of varying sizes, creating a layered, organic shape.
- Back-up slides

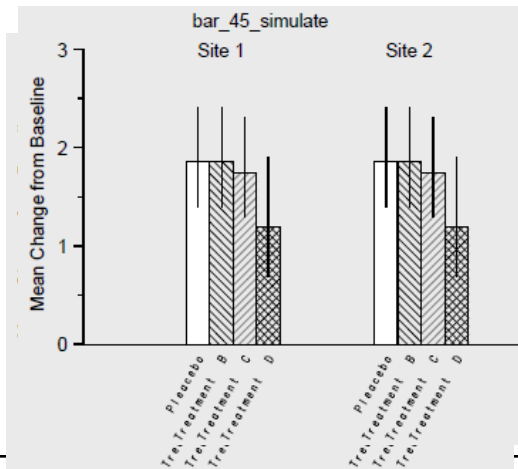
# Next-Generation Graphics: B3-enhancement.sas--Common options

| PLOT-statement                                                                                                                                                                                                                                                                                                                                | TITLE                                                                                                                                                                                                                                                                                                           | FOOTNOTE                                                                                                                                                                                                                                                                                                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DISCRETEOFFSET</b> = number<br><b>GROUP</b> = group-variable<br><b>GROUPDISPLAY</b> =CLUSTER   OVERLAY   STACK<br><b>JITTER</b><br><b>MARKERATTRS</b> = (color= symbol= size=)<br><b>LINEATTRS</b> = (color= pattern= thickness=)<br><b>FILLATTRS</b> = (color= transparency=0.5)                                                          | <b>JUSTIFY</b> =left   center   right<br><b>COLOR</b> = black   red   green   blue ...<br><b>HIGH</b> = n (1: font size 12, 2 font size 24 ...)<br><b>BOLD</b><br><b>ITALIC</b>                                                                                                                                 | <b>JUSTIFY</b> =left   center   right<br><b>COLOR</b> = black   red   green   blue ...<br><b>HIGH</b> = n (1: font size 12, 2 font size 24 ...)<br><b>BOLD</b><br><b>ITALIC</b>                                                                                                                          |
| AXIS                                                                                                                                                                                                                                                                                                                                          | Scatter Plot                                                                                                                                                                                                                                                                                                    | LEGEND                                                                                                                                                                                                                                                                                                   |
| <b>LABEL</b> = "text string"<br><b>MIN</b> = min-number<br><b>MAX</b> = max-number<br><b>OFFSETMIN</b> = 0.05<br><b>OFFSETMAX</b> = 0.05<br><b>DISPLAY</b> = (nolabel noline noticks novalues)<br><b>TICKVALUEFORMAT</b> = sas-format<br><b>GRID</b><br><b>COLORBANDS</b> = none   even   odd<br><b>TYPE</b> = discrete   linear   log   time |                                                                                                                                                                                                                                                                                                                 | <b>TITLE</b> = "text string"<br><b>LOCATION</b> = outside   inside<br><b>POSITION</b> = bottom   top<br>  right   left<br>  topleft   topright<br>  bottomleft   bottomright<br><b>OUTERPAD</b> = (top = n1 bottom = n2<br>Left = n3 right = n4)<br><b>ACROSS</b> = n <b>DOWN</b> = m<br><b>NOBORDER</b> |
| TEXT                                                                                                                                                                                                                                                                                                                                          | INSET                                                                                                                                                                                                                                                                                                           | REFLINE                                                                                                                                                                                                                                                                                                  |
| <b>TEXT</b> x=x-var y=y-var text=variable<br>/ position = top   bottom   left   right   topleft<br><b>SPLITCHAR</b> ="character"<br>outline backfill strip                                                                                                                                                                                    | <b>INSET</b> ("string-1" "string-2" ... "string-n") OR<br>("label-1" = "value-1" ... "label-n" = "value-n")<br>/ title = "text-string"<br>position = top   bottom   left   right   topleft   ...<br>labelalign = left   center   right<br>valuealign = left   center   right<br><b>BORDER</b>   <b>NOBORDER</b> | <b>REFLINE</b> value-list   variable<br>/ axis=x y<br>lineattrs=(color= pattern= thickness= )<br>transparency=0.5                                                                                                                                                                                        |

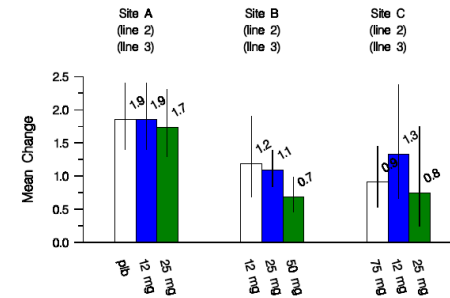
# C1-barchart

## Parallel to the legacy macro %gbars

### Bar Chart in User Document of %gbars



Grouped



□ n=7

■ n=12

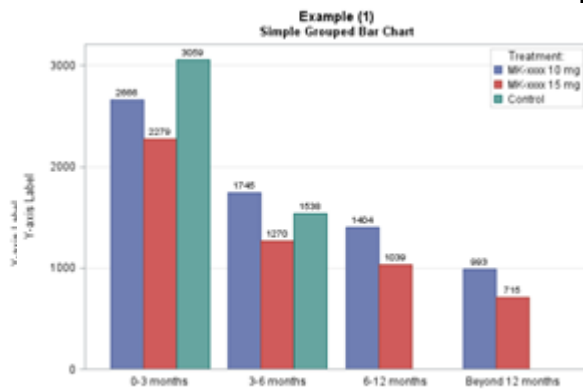
■ n=35

Cases  
Patients at Risk  
Patients Number

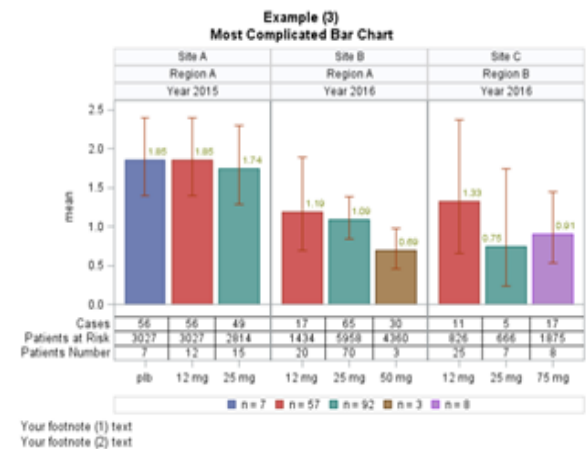
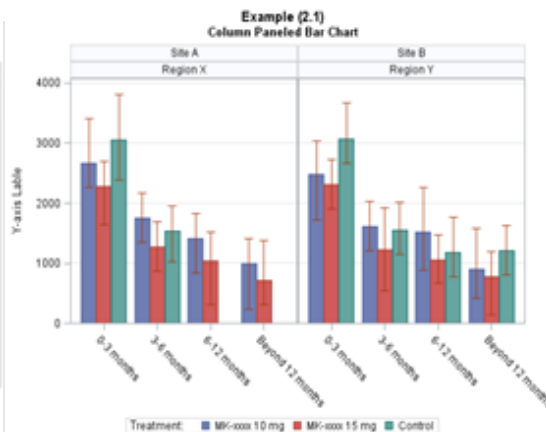
| Cases            | 56   | 56   | 49   | 17   | 65   | 30   | 17   | 11  | 5   |
|------------------|------|------|------|------|------|------|------|-----|-----|
| Patients at Risk | 3027 | 3027 | 2814 | 1434 | 5958 | 4360 | 1875 | 666 | 666 |
| Patients Number  | 7    | 12   | 15   | 20   | 70   | 3    | 8    | 25  | 7   |

Paneled

Complicated



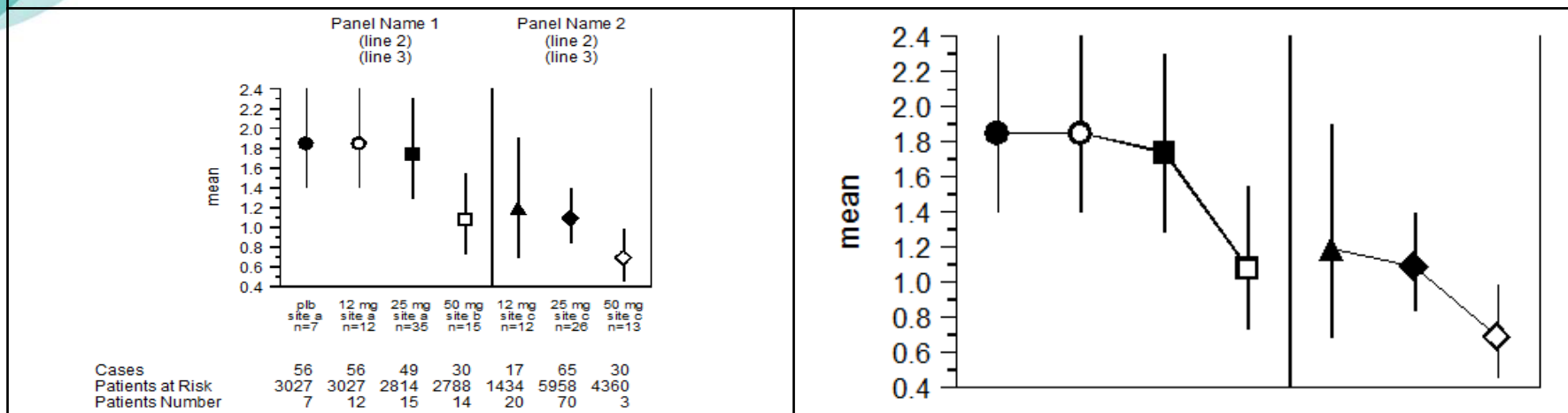
footer (1)  
footer (2)  
footer (1)  
footer (2)



# C2-barplot

## Parallel to the legacy macro %gpanel

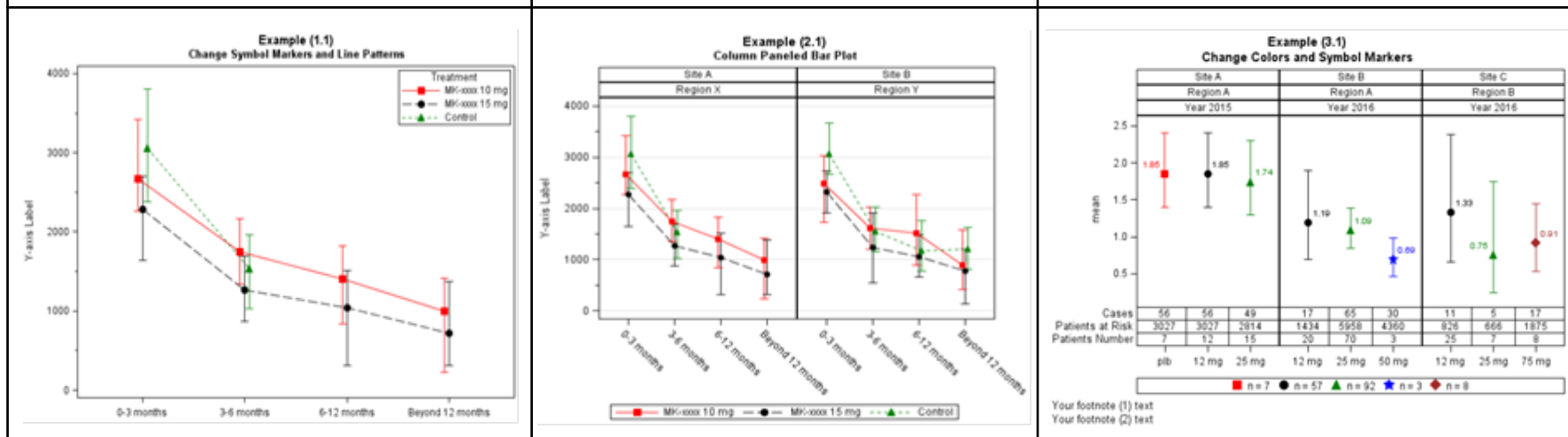
### Bar Plots in User Document for %gpanel



### Grouped

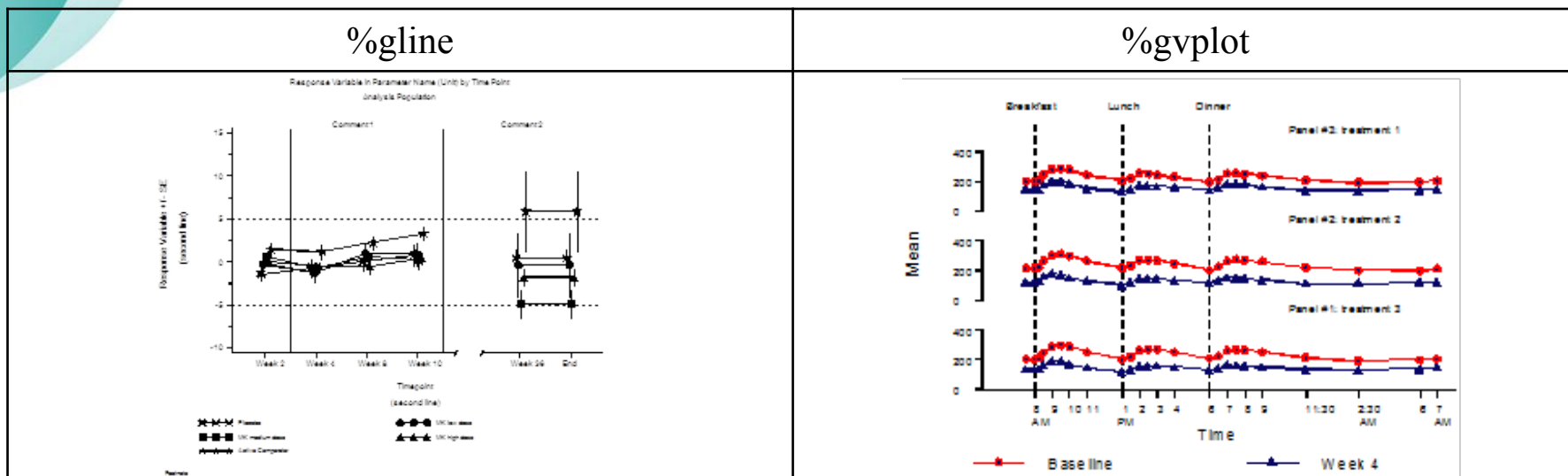
### Paneled

### Complicated



# C3-seriesplot

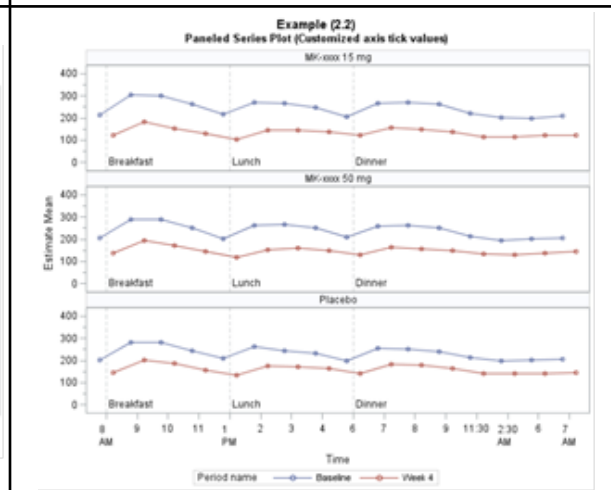
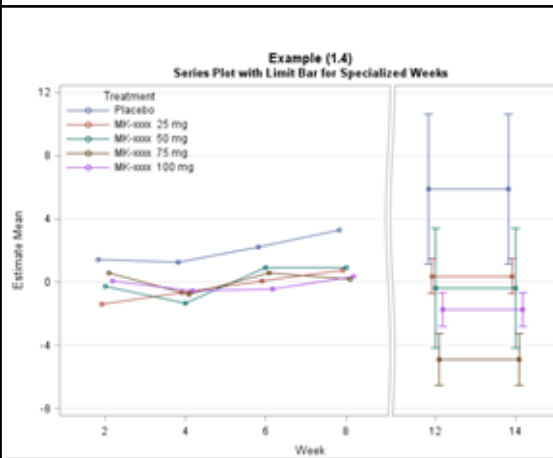
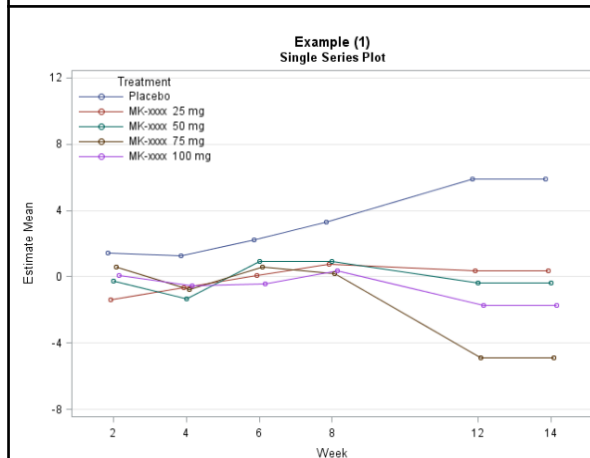
## Parallel to G-macros %gline, %gvplot



General series plot by group

Add error bars & axis break

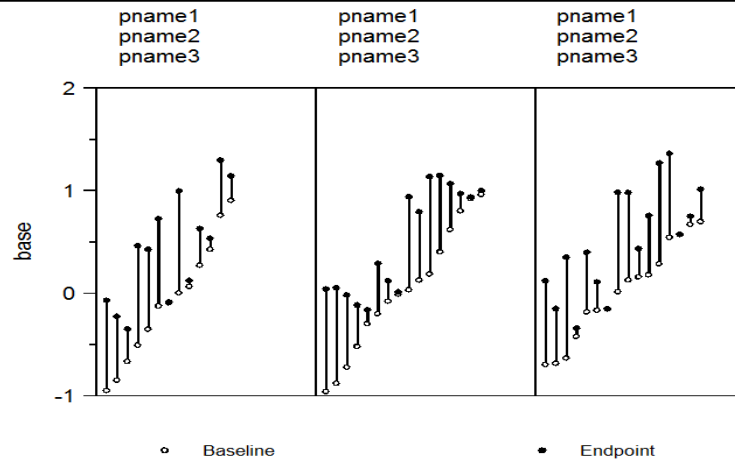
Paneled series plot



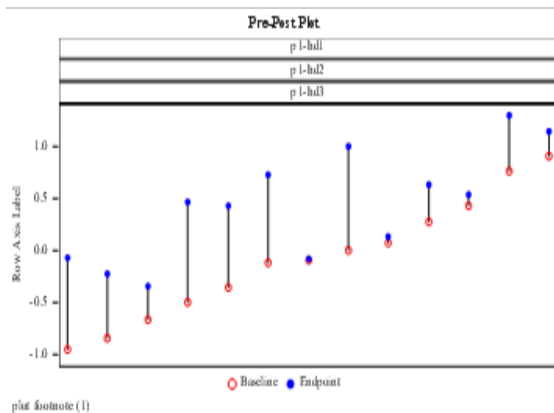
# C4-highlowplot

## Parallel to legacy macro %gprepost

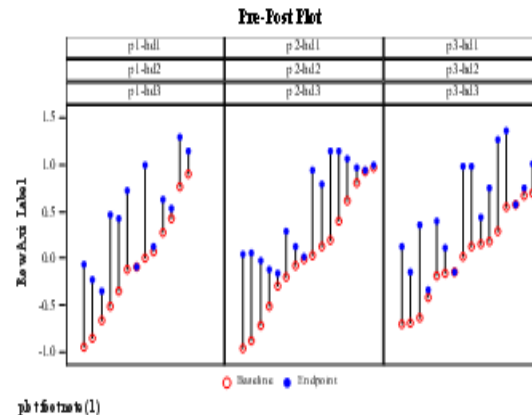
Prepost Plot in User Document for %gprepost



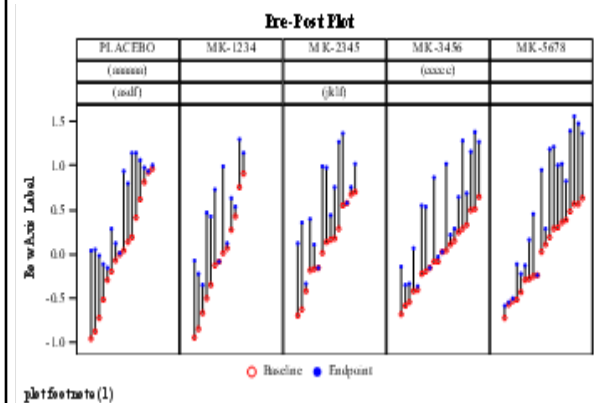
One Cell Prepost plot



Paneled Prepost Plot



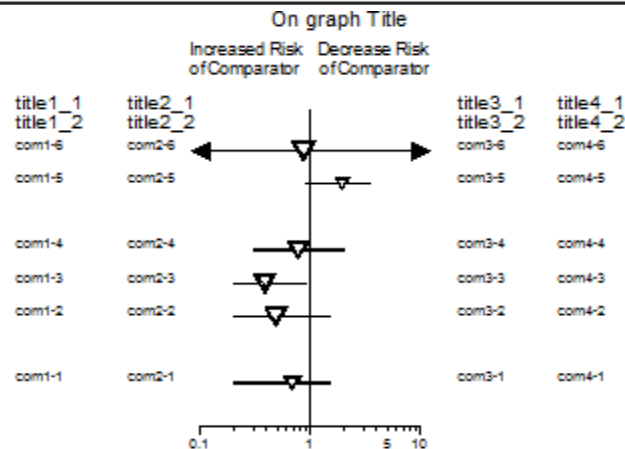
Blank Panel header labels



# C5-forestplot

## Parallel to legacy macro %gmeta

**Forest Plot in User Document of %GMETA**



**Baseline Characters**

**Demographic Characters**

# M1-rainfallplot & M2-volcanoplot In Development as Standard Macros

| %rainfallplot |
|---------------|
|               |
| %volcanoplot  |
|               |

# Useful Reference Tables

## Color Name and RGB Code

|             |         |            |         |              |         |
|-------------|---------|------------|---------|--------------|---------|
| WHITE       | #FFFFFF | RED        | #FF0000 | GREEN        | #00FF00 |
| BLUE        | #0000FF | MAGENTA    | #FF00FF | CYAN         | #00FFFF |
| YELLOW      | #FFFF00 | BLACK      | #000000 | AQUAMARINE   | #70DB93 |
| BLUE VIOLET | #9F59F9 | BRASS      | #B5A642 | BRIGHT GOLD  | #D9D919 |
| BROWN       | #A62A2A | BRONZE     | #8C7853 | BRONZE II    | #A67D3D |
| CADET BLUE  | #5F99F9 | COPPER     | #B87333 | CORAL        | #FF7F00 |
| DARK BROWN  | #5C4033 | DARK GREEN | #2F4F2F | DARK WOOD    | #855E42 |
| DARK PURPLE | #871F78 | DARK TAN   | #97694F | DIM GREY     | #545454 |
| DUSTY ROSE  | #856363 | FIREBRICK  | #8E2323 | FOREST GREEN | #238E23 |
| GOLD        | #CD7F32 | GREY       | #C0C0C0 | INDIAN RED   | #4E2F2F |
| KHAKI       | #9F9F5F | LIME GREEN | #32CD32 | MAROON       | #8E236B |
| NAVY BLUE   | #23238E | ORANGE     | #FF7F00 | ORCHARD      | #DB70DB |
| PINK        | #BC8F8F | PLUM       | #EAADEA | SCARLET      | #8C1717 |
| SILVER      | #E0E8FA | STEEL BLUE | #236B8E | TAN          | #DB9370 |
| TURQUOISE   | #A0E0E0 | VIOLET     | #4F2F4F | WHEAT        | #D8D8BF |

## Line Pattern

| Pattern Number | Pattern Name        | Example     |
|----------------|---------------------|-------------|
| 1              | Solid               | —————       |
| 2              | ShortDash           | - - - - -   |
| 4              | MediumDash          | - - - - -   |
| 5              | LongDash            | - - - - -   |
| 8              | MediumDashShortDash | - - - - -   |
| 14             | DashDashDot         | - - - - -   |
| 15             | DashDotDot          | - . - . - . |
| 20             | Dash                | - - - - -   |
| 26             | LongDashShortDash   | - - - - -   |
| 34             | Dot                 | . . . . .   |
| 35             | ThinDot             | . . . . .   |
| 41             | ShortDashDot        | - . - . - . |
| 42             | MediumDashDotDot    | - - - - -   |

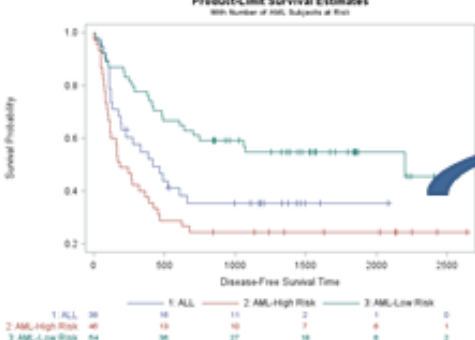
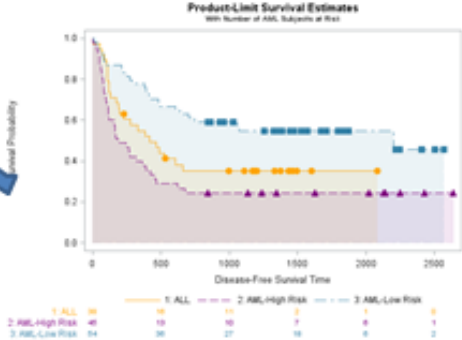
## Symbol Marker

|                |   |                     |   |
|----------------|---|---------------------|---|
| ArrowDown      | ↓ | StarFilled          | ★ |
| Asterisk       | ✱ | Tack                | ⌞ |
| Circle         | ○ | Tilde               | ~ |
| CircleFilled   | ● | Triangle            | △ |
| Diamond        | ◇ | TriangleFilled      | ▲ |
| DiamondFilled  | ◆ | TriangleDown        | ▽ |
| GreaterThan    | > | TriangleDownFilled  | ▼ |
| Hash           | # | TriangleLeft        | ◀ |
| HomeDown       | ⏏ | TriangleLeftFilled  | ◀ |
| HomeDownFilled | ⏏ | TriangleRight       | ▷ |
| IBeam          | ⎵ | TriangleRightFilled | ▶ |
| LessThan       | < | Union               | ∪ |
| Plus           | + | X                   | × |
| Square         | □ | Y                   | Y |
| SquareFilled   | ■ | Z                   | Z |
| Star           | ☆ |                     |   |

## Unicode for Specific Characters

| Description           | Displayed      | Unicode                               |
|-----------------------|----------------|---------------------------------------|
| R Square              | R <sup>2</sup> | R{unicode '00B2'}x                    |
| y hat                 | ŷ              | y{unicode hat}                        |
| infinity              | ∞              | {unicode '221e'}x                     |
| less than or equal    | a ≤ b          | a {unicode '2264'}x b                 |
| greater than or equal | b ≥ a          | b {unicode '2265'}x a                 |
| almost equal          | a ≈ b          | a {unicode '2248'}x b                 |
| alpha                 | α A            | {unicode alpha} {unicode alpha_u}     |
| beta                  | β B            | {unicode beta} {unicode beta_u}       |
| gamma                 | γ Γ            | {unicode gamma} {unicode gamma_u}     |
| delta                 | δ Δ            | {unicode delta} {unicode delta_u}     |
| epsilon               | ε E            | {unicode epsilon} {unicode epsilon_u} |
| zeta                  | ζ Z            | {unicode zeta} {unicode zeta_u}       |
| eta                   | η H            | {unicode eta} {unicode eta_u}         |
| theta                 | θ Θ            | {unicode theta} {unicode theta_u}     |
| iota                  | ι I            | {unicode iota} {unicode iota_u}       |
| kappa                 | κ K            | {unicode kappa} {unicode kappa_u}     |
| lambda                | λ Λ            | {unicode lambda} {unicode lambda_u}   |
| mu                    | μ M            | {unicode mu} {unicode mu_u}           |
| nu                    | ν N            | {unicode nu} {unicode nu_u}           |
| xi                    | ξ Ξ            | {unicode xi} {unicode xi_u}           |
| omicron               | ο Ο            | {unicode omicron} {unicode omicron_u} |
| pi                    | π Π            | {unicode pi} {unicode pi_u}           |
| rho                   | ρ P            | {unicode rho} {unicode rho_u}         |
| sigma                 | σ Σ            | {unicode sigma} {unicode sigma_u}     |
| tau                   | τ T            | {unicode tau} {unicode tau_u}         |
| upsilon               | υ Υ            | {unicode upsilon} {unicode upsilon_u} |
| phi                   | φ Φ            | {unicode phi} {unicode phi_u}         |
| chi                   | χ X            | {unicode chi} {unicode chi_u}         |
| psi                   | ψ Ψ            | {unicode psi} {unicode psi_u}         |
| omega                 | ω Ω            | {unicode omega} {unicode omega_u}     |

# Next Generation Graphics FAQ, SG annotate

|                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>1. How to change the plot attributes (colors, fill colors, markers, line patterns) for group data?</b>                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                                                                                                                                                                                                                                                                      | <b>1.1 Attribute Priority</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                                                                                                                                                       | <b>1.2 Customize style using PROCTEMPLATE</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                                                                                                                                                                                                                                                                                                                                                       | <b>1.3 MACRO %MODSTYLE</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                       | <b>1.4 SG Attribute Map</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                       | <b>1.5 STYLEATTRS statement (SAS 9.4)</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>2. How to save the output plot?</b>                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Save plot to image (.png) file</b><br>How I can change/save SGPLOTx.png to my expected name/place?<br><pre>ods html gpath="&amp;outdir" style=myRTF; ods graphics / imagename="PLOT2PNG";</pre>                                                                                                                                                    | <b>Save plot to rtf file.</b><br>How I can write the titles/footnotes out of graph area?<br><pre>ods rtf file="&amp;outdir\PLOT2RTF.rtf" bodytitle nogtitle nogfootnote style=myRTF; ods graphics / noborder;</pre>                                                                                                                                                                                                                                                                             |
| <b>SGPLOT/SGPANEL/SGRENDER to generate plot.</b><br><pre>ods html close;</pre>                                                                                                                                                                                                                                                                        | <b>SGPLOT/SGPANEL/SGRENDER to generate plot.</b><br><pre>ods rtf file="&amp;outdir\PLOT2RTF.rtf" close;</pre>                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>3. How to change font in output plot?</b><br>To change style 'font' from parent                                                                                                                                                                                                                                                                    | <b>4. SG Annotate</b><br>Example to add Confidential Text                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <pre>proc template; define style myRTF; parent = styles.rtf; style fonts / 'TitleFont2' = ("Times New Roman, Arial", 11pt, normal) 'TitleFont' = ("Times New Roman, Arial", 11pt, normal) 'StrongFont' = ("Times New Roman, Arial", 10pt, bold) 'EmphasisFont' = ("Times New Roman, Arial", 10pt, italic) ..... end; run; ods html style=myRTF;</pre> | <pre>data anno; function='text'; label='CONFIDENTIAL'; textsize=54; textcolor='gray'; justify='right'; transparency=0.8; rotate=25; width=200; run;  proc sgplot data=plots sganno=anno; band x=Time upper=Survival lower=0 / group=Stratum type=step; step x=Time y=Survival / group=Stratum name='s'; scatter x=Time y=censored / markerattrs=(size=11) group=stratum; xaxis table atrisk / x=tatrisk class=stratum colorgroup=stratum location=outside; keylegend 's' / noborder; run;</pre> |