Accessibility and ODS Graphics: Seven Simple Steps to Section 508 Compliance Using SAS® 9.4M5

Ed Summers, Julianna Langston, and Dan Heath, SAS Institute Inc., Cary, NC

ABSTRACT

How do you create data visualizations that comply with the Section 508 amendment to the United States Workforce Rehabilitation Act, the Web Content Accessibility Guidelines (WCAG), and other accessibility standards? It's easy when you use the new Output Delivery System (ODS) Graphics accessibility features in SAS® 9.4M5. This paper defines seven simple steps to create accessible data visualizations. The accessibility requirements that are satisfied by each step are explained, and additional references are provided. It includes sample code for real-world examples that has been tested by the SAS® accessibility team. It also includes a handy one-page checklist that you can print separately for future reference.

INTRODUCTION

This paper explains how to create graphs that can be perceived and understood by people with disabilities including people with visual impairments or total blindness. Due to the highly visual nature of the content, the needs of people with visual impairments or blindness are a primary concern. That said, you don't have to sacrifice aesthetics for accessibility. Rather, you will learn how to create graphs that are modern, visually appealing, and accessible to people with a wide range of abilities.

There are three groups that are impacted by the accessibility of graphs or a lack thereof:

1. End users with disabilities who need to access graphs.

2. SAS programmers who create graphs.

3. Accessibility compliance professionals who are formally responsible for ensuring that an organization complies with accessibility requirements.

The target audience for this paper is SAS programmers with firm accessibility requirements. Accessibility requirements are typically mandated by law. They are sometimes reinforced by a settlement or decision that is the result of legal action that was initiated by a person with a disability. Accessibility requirements are typically enforced within an organization by compliance officers within the Legal, Communications, or IT departments. The topic of accessibility might be unfamiliar to SAS programmers just like SAS is unfamiliar to accessibility compliance professionals. This paper will help bridge the gap.

The scope of this paper is non-interactive graphs created by SAS 9.4M5 (or later) using the ODS Statistical Graphics procedures. Some exceptions as of the time of writing are enumerated in step 1 below.

Some of the recommendations in this paper will be immediately obvious and easy to understand for the reader with typical vision, for example, recommendations for text size or color. However, the ODS Graphics system in SAS 9.4M5 supports a radically innovative new feature that enables users with disabilities to re-render your data visualizations in ways that adapt to their unique needs. For example, users with a learning disability can generate a text description that helps them understand the components of a graph, users with low-vision can re-render a graph using a different visual style so that they can see it better, or users with total blindness can interactively explore a graph using sound so that they can quickly perceive trends and outliers.

The consequence of this innovation is that the graphs you create are no longer static artifacts that can only be perceived using vision. They are now dynamic artifacts that can be re-rendered in an infinite number of ways. As a result, you might need to provide additional information that might not make sense for the default visual presentation of the graph that you create. This concept might sound abstract;

however, if you follow the concrete recommendations in this paper, you will quickly meet the needs of users with disabilities without becoming an accessibility expert.

RELEVANT ACCESSIBILITY REQUIREMENTS

There are two types of accessibility requirements: technical criteria and functional performance criteria. A full discussion of the requirements is beyond the scope of this paper. Rather, we will provide a very high-level summary and list the requirements that are relevant for static graphs.

TECHNICAL CRITERIA

Over the last decade, governments around the world have worked to harmonize their technical criteria. As a result, most accessibility legislation directly references or is closely aligned with the Web Content Accessibility Guidelines (WCAG) version 2.0 at the AA level of conformance. WCAG 2.0 defines 12 guidelines. One or more testable success criteria are defined for each guideline. Each success criterion maps to a specific level of conformance. The relevant guidelines and corresponding AA success criteria are listed below for your convenience.

- Guideline 1.1 Text Alternatives - Provide text alternatives for any non-text content so that it can be changed into other forms that people need, such as large print, braille, speech, symbols, or simpler language:

    - Success Criterion 1.1.1 Non-text Content

- Guideline 1.3 Adaptable - Create content that can be presented in different ways (for example, simpler layout) without losing information or structure:

    - Success Criterion 1.3.1 Info and Relationships

    - Success Criterion 1.3.2 Meaningful Sequence

- Guideline 1.4 Distinguishable - Make it easier for users to see and hear content including separating foreground from background:

    - Success Criterion 1.4.1 Use of Color

    - Success Criterion 1.4.3 Contrast (Minimum)

    - Success Criterion 1.4.4 Resize Text

- Guideline 3.1 Readable - Make text content readable and understandable:

    - Success Criterion 3.1.1 Language of Page

    - Success Criterion 3.1.2 Language of Parts

- Guideline 4.1 Compatible - Maximize compatibility with current and future user agents, including assistive technologies:

    - Success Criterion 4.1.1 Parsing

FUNCTIONAL PERFORMANCE CRITERIA

While technical criteria are specific to certain types of content, functional performance criteria consider the content or system as a whole and they assess whether people with specific types of disabilities can actually use the system for the purpose that it was designed to perform. Functional performance criteria get to the heart of the matter, that is, can people with disabilities actually use the content?

Functional performance criteria have also been harmonized globally. This paper will refer to the Revised Section 508 Information and Communication (ICT) Standards and Guidelines that were published in the Federal Register on January 18, 2017.

The following Revised Section 508 functional performance criteria are relevant for static graphs:

- 302.1 Without Vision. Where a visual mode of operation is provided, ICT shall provide at least one

mode of operation that does not require user vision.

- 302.2 With Limited Vision. Where a visual mode of operation is provided, ICT shall provide at least one mode of operation that enables users to make use of limited vision.

- 302.3 Without Perception of Color. Where a visual mode of operation is provided, ICT shall provide at least one visual mode of operation that does not require user perception of color.

- 302.9 With Limited Language, Cognitive, and Learning Abilities. ICT shall provide features making its use by individuals with limited cognitive, language, and learning abilities simpler and easier.

STEP 1: USE THE ODS HTML5 DESTINATION WITH STYLE=DAISY AND ACCESSIBLE_GRAPH

Cut and paste this code into the beginning of your SAS program to lay the foundation for accessible graphs:

```
/* 1 */ ods html5 style=Daisy accessible_graph;
/* 2 */ ods escapechar="^";
/* 3 */ proc odstext;
/* 4 */   p "Accessibility: This page contains data visualizations that can
be viewed in alternative formats. Install ^{style
[url='https://support.sas.com/software/products/graphics-
accelerator/index.html'] SAS Graphics Accelerator} to generate text
descriptions, view underlying data in a tabular format, or interactively
explore data visualizations using sound. ";
/* 5 */ run;
```

The ODS HTML5 destination is the best choice for SAS customers who have firm accessibility requirements. SAS has invested heavily in the accessibility of ODS HTML5 in general and some of the accessibility features described in this paper are available only in that destination.

The Daisy style was designed with accessibility in mind. Daisy will produce output that is both visually appealing and accessible, provided you do not override style elements or attributes. If you do need to use overrides, work with your accessibility compliance professional to evaluate your output against accessibility requirements.

The ACCESSIBLE_GRAPH option facilitates one of the most critical needs of users with disabilities, which is to access graphics content using alternative methods and modalities. It is not possible to create a single presentation of a graph that meets the needs of all users. Ideally, each user can access a graph in a way that meets their specific abilities and disabilities.

When you enable the ACCESSIBLE_GRAPH option, ODS Graphics will include accessibility metadata within each graph. The accessibility metadata is a presentation-independent representation of the corresponding graph. It is not visible to the naked eye. It can only be accessed using a companion product called SAS Graphics Accelerator.

SAS Graphics Accelerator is a free browser extension. Users with disabilities can use it to view alternative presentations of a graph. For example, they can generate a text description, view the data underlying the graph in a tabular format, re-render the graph with a style that is optimized for users with low vision, or interactively explore the graph using sound. However, users with disabilities must install SAS Graphics Accelerator to access these features. Therefore, you must include an "accessibility statement" somewhere in your SAS output that informs users with disabilities about SAS Graphics Accelerator and provides a link so that they can install it.

Line 1 in the sample code above enables the ACCESSIBLE_GRAPH option in the ODS HTML5 statement so that accessibility metadata will be embedded in every graph.

Lines 2-5 in the sample code above tell users with disabilities how to access alternative presentations of your graphs.

In 9.4M5, all the ODS Statistical Graphics procedures except the SGMAP procedure produce accessibility metadata when the ACCESSIBLE_GRAPH option is enabled. We are continually working to expand the graph types supported by SAS Graphics Accelerator. As of the time of this writing, which is January 2018, SAS Graphics Accelerator supports the following graph types:

- VBAR / HBAR

- VBOX / HBOX

- BUBBLE

- HEATMAP

- HIGHLOW

- HISTOGRAM

- VLINE / HLINE

- SCATTER

- SERIES

We ship a new version of SAS Graphics Accelerator every few months. Check the SAS Graphics Accelerator product page for the most recent list of supported graph types.

STEP 2: USE THE SCALABLE VECTOR GRAPHICS (SVG) OUTPUT FORMAT

There are two types of graphics formats: vector and raster. Vector formats allow users to magnify an image while maintaining clarity. On the other hand, raster formats become blurry as they are magnified.

For example, the images below are screenshots of graphs that were magnified by 500% using the standard zoom feature available in all modern browsers. The SVG output maintains its quality, while the raster-based PNG output looks blurry and pixelated.

Figure 1. SVG Output

Figure 2. PNG Output
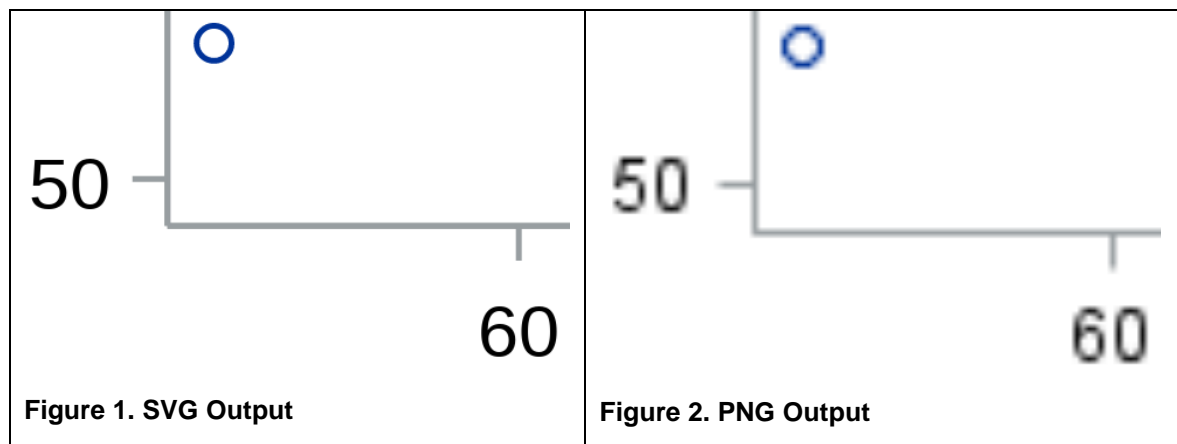
The following sample code sets SVG as the output format using the OUTPUTFMT option and includes a few additional options that will be explained in the next section:

```
ods graphics / outputfmt=svg imagemap attrpriority=NONE;
```

STEP 3: USE DATA TIPS, MARKERS, LINE PATTERNS, AND FILL PATTERNS IN ADDITION TO COLOR

It is perfectly fine to use color to convey meaning in your graphs. For example, you might use color to distinguish between groups in a grouped bar chart or distinguish between series in a series plot with

multiple series. The problem arises when color is the only visual property that is used to convey meaning. You can avoid this problem by following the recommendations below.

First, enable data tips on all graphs so that users with low vision or color-blindness can distinguish between groups, series, and so on, by hovering over data elements. Data tips are enabled for all graphs in the following ODS GRAPHICS statement using the IMAGEMAP option:

```
ods graphics / outputfmt=svg imagemap attrpriority=NONE;
```

Second, force ODS Graphics to cycle through markers and line patterns in all relevant graphs by setting ATTRPRIORITY=NONE. Some ODS styles set ATTRPRIORITY=COLOR by default, which will prevent marker shapes and line patterns from changing until the style colors have been exhausted. Setting ATTRPRIORITY in the ODS GRAPHICS statement will override the style setting. Setting this option is particularly important for many commonly used line and marker plots, such as the following:

- SCATTER

- SERIES

- STEP

- VLINE / HLINE

- Fit plots (REG, LOESS, and PBSPLINE)

The graphs below show how the accessibility of a VLINE chart improves by letting more of the visual attributes to change per group value. Here is the code to create the chart:

```
proc sgplot data=sashelp.class;
   vline age / response=weight stat=mean group=sex markers;
run;
```
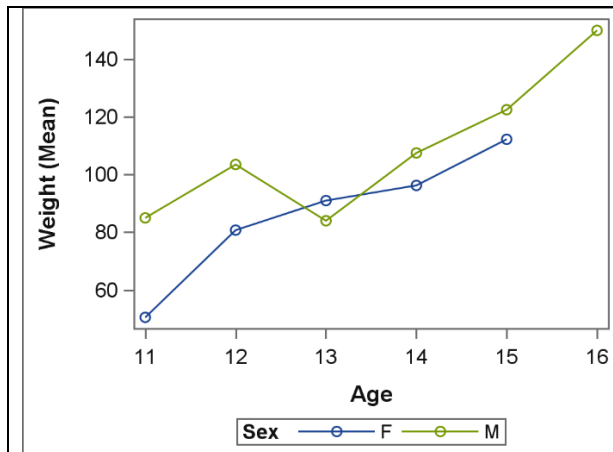

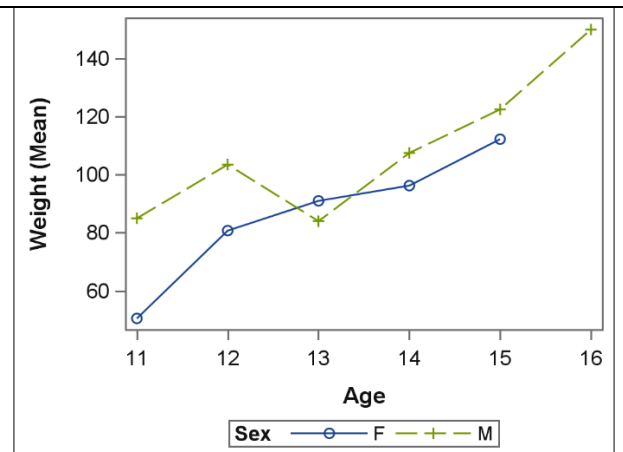**Figure 3. ATTRPRIORITY=COLOR**

Figure 4. ATTRPRIORITY=NONE

Third, force ODS Graphics to use fill patterns by specifying the FILLPATTERN option on all relevant statements in the SGPLOT procedure. Fill pattern can be used with or without fill colors. To use only fill patterns, you might need to use the NOFILL option along with the FILLPATTERN option if the ODS style has the fill color turned on by default (most styles do). In the following example, we created a grouped bar chart that uses both fill colors and fill patterns to distinguish between groups:

```
proc sgplot data=sashelp.class;
   vbar age / response=weight stat=mean group=sex
              groupdisplay=cluster fillpattern;
run;
```

The graphs below show how just using the FILLPATTERN option improves the accessibility of bar charts. It is important that the ATTRPRIORITY option be set to NONE so that the fill patterns will change with the colors. Otherwise, the same pattern will be used for the entire color list.
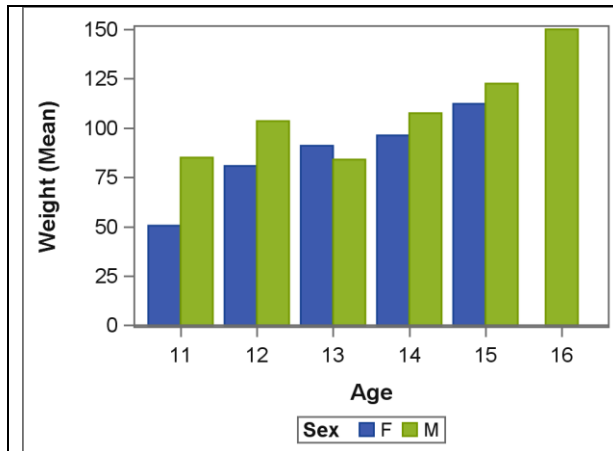

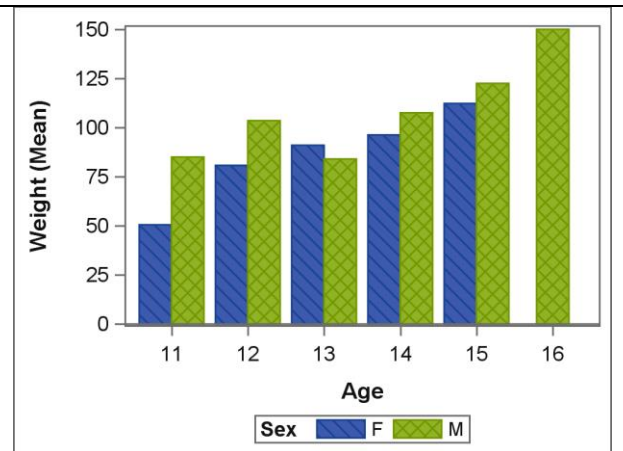**Figure 5. Fill Colors Only**

Figure 6. Fill Colors with Fill Patterns

Fill pattern support has been greatly expanded in the SAS 9.4M5 release of the ODS Graphics system. Plots and charts that now have FILLPATTERN support include the following:

- VBAR / HBAR
- HISTOGRAM
- VBOX / HBOX
- BUBBLE
- BAND
- ELLIPSE
- POLYGON
- HIGHLOW (using TYPE=BAR)

Finally, you might want to control certain visual attributes directly from the procedure syntax instead of relying completely on the ODS style. This can be done a couple of different ways. First, you can override the list of colors, patterns, and markers by using the STYLEATTRS statement in SGPLOT and SGPANEL, or the corresponding options in the SGSCATTER procedure statement. This approach is most useful for grouped plots and charts. In the following example, I wanted to make the patterns be L4 and R4 in the grouped bubble plot. I used the DATAFILLPATTERN option in the STYLEATTRS statement to override the patterns from the style. The NOFILL and FILLPATTERN options were used to create bubbles filled with patterns only.

```
ods graphics / attrpriority=none;
proc sgplot data=sashelp.class;
    styleattrs datafillpatterns=(L4 R4);
    bubble x=age y=weight size=height /
           nofill fillpattern group=sex;
run;
```
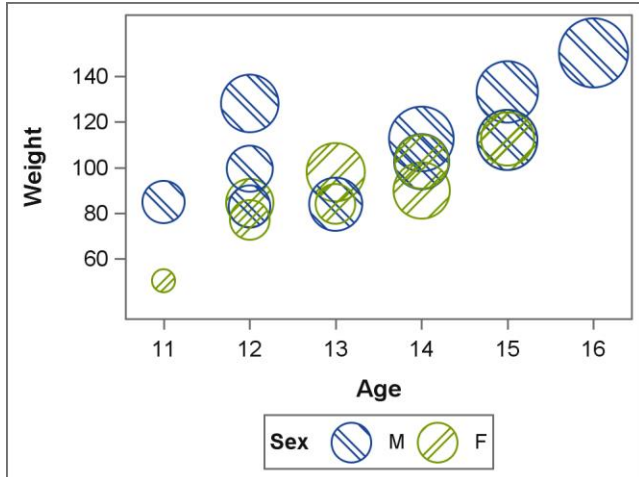
Figure 7. Bubble Plot with Patterns

For non-grouped charts and plots, you might want to change the attributes directly in the plot statement instead of overriding the style. In the following example, I overlaid two line charts, while specifying the color and line patterns directly on each chart.

```
ods graphics / attrpriority=none;
proc sgplot data=sashelp.class;
   vline age / response=weight stat=mean
         lineattrs=(color=blue pattern=longdash);
   vline age / response=height stat=mean
         lineattrs=(color=red pattern=dash);
run;
```
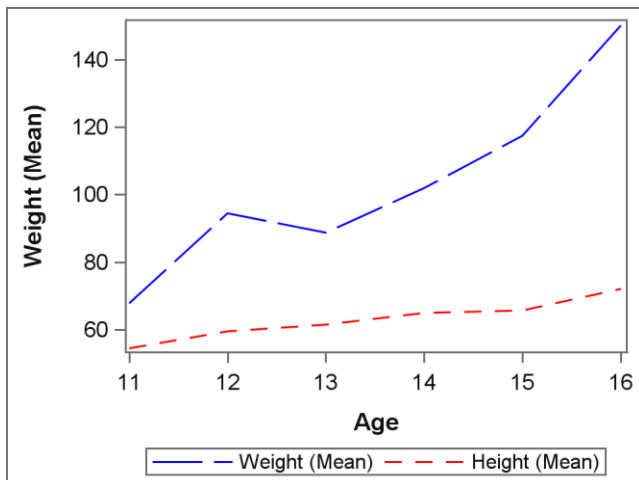

Figure 8. Overlaid Line Charts with Patterns

STEP 4: SPECIFY A DESCRIPTION

You should **always** specify a description on your graphs using the DESCRIPTION option. The description is a critical piece of information that is particularly important to users with visual impairments or blindness because they can read the description using special software called screen readers. Screen readers use text-to-speech technology to convert text such as the description on your graph into speech that can be heard. Note that the description you provide is not visible in the default visual presentation of your graphs. Rather, it serves as a text alternative for your graph when the graph is encountered within a web page.

The description should help users with visual impairments or blindness quickly:

1. Disambiguate a specific graph from all the other graphs on the page.

2. Determine if they want to generate alternative presentations of the graph so that they can explore the graph in more detail.

Follow these guidelines when writing descriptions for your graphs:

1. Descriptions should be as brief as possible. Less is more. A succinct phrase will suffice. Descriptions should never be full sentences.

2. Describe the graph in terms of the variables presented within the graph.

3. If there are two graphs on the page that show the same information for two different objects, be sure to disambiguate the graphs in your description for each.

4. Do not describe the data in the graph. Users with disabilities use alternative presentations of the graph to understand the data including trends, outliers, and so on.

5. When in doubt, use the same text you would use for the visible title of the graph.

The following examples satisfy the goals and guidelines listed above:

1. Sales by region

2. Net profit by quarter grouped by product line

3. Customer satisfaction by store

4. Average customer wait time for store A

5. Average customer wait time for store B

It is also a best practice to include a title in every graph although it is not strictly required for accessibility. If you do specify a title, make sure the title is displayed within the graph. In other words, do not use the NOGTITLE option to move the title outside the graph display area because the SAS Graphics Accelerator can access the title only if it is displayed within the graph area.

STEP 5: SPECIFY VARIABLE VALUES USING PLAIN LANGUAGE

Variable values can appear in your graphs in a variety of places such as axis labels for grouped graphs, legends, and data tips. It can be difficult for some users to understand your graphs if they include jargon, abbreviations, or acronyms. For example, the SASHELP.CLASS sample data set includes a variable that specifies the sex of each student in a class. The values of this variable can be "F" or "M". Users with cognitive, language, learning, and visual disabilities might find it difficult to understand those abbreviations.

It is a best practice to use complete words and plain language in all text that might be presented to users within your graphs. Therefore, use a user-defined format to translate variable values into plain language. For example, the following code creates a user-defined format and assigns it to a variable within the SGPLOT procedure:

```
proc format;
  Value $sex 'F'='Female' 'M'='Male';
run;
proc sgplot data=sashelp.class description='Students by sex';
  format sex $sex.;
  vbar sex;
run;
```
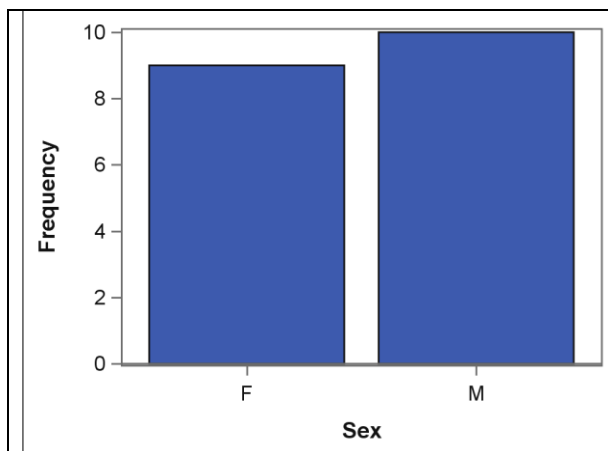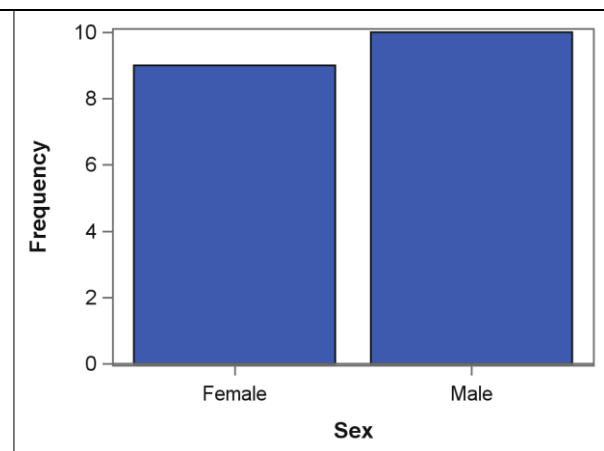
| Figure 9. Without Format | Figure 10. With Format |

STEP 6: SPECIFY AXIS LABELS

The default visual presentation of a graph on your computer screen might not have space for axis labels. Plus, axis labels can add clutter that reduces readability for users with typical vision. You might reasonably expect users with typical vision to derive the axis labels from content surrounding a specific graph. So, you might remove one or more axis labels from your graph using the DISPLAY option in the YAXIS or XAXIS statement of SGPLOT. However, users with total blindness will use SAS Graphics Accelerator to interactively explore a non-visual presentation of your graph without the surrounding context, so they need a reasonable label for each axis even though axis labels do not appear in the default visual presentation of the graph.

SAS Graphics Accelerator will use the following order of precedence to derive values for axis labels:

- The temporary label that was assigned within a YAXIS or XAXIS statement within the SGPLOT procedure call that created the graph.

- The label that was temporarily assigned to the variable within the SGPLOT procedure call that created the graph.

- The label that was permanently assigned to the variable within a DATA step.

- The name of the variable.

As a result of this precedence, variable labels and values might appear in alternative presentations of your graphs that are created by SAS Graphics Accelerator even though they do not appear in the default visual presentation you see on your screen.

It is a best practice to permanently assign a label to every variable using the LABEL statement within a DATA step. This practice will ensure that a reasonable label is available for all variables. The following sample code sets a permanent label on three variables using plain language:

```
data work.cars;
set sashelp.cars;
  label msrp = 'Manufacturer Suggested Retail Price';
  label mpg_city = 'Miles Per Gallon (City)';
  label mpg_highway = 'Miles Per Gallon (Highway) ';
run;
```

Use the rules of precedence above to override the permanent variable labels as needed. If you must hide an axis label from the default visual presentation of a graph, you can use the DISPLAY option in the XAXIS or YAXIS statements. For example, the XAXIS statement below will hide the specified label from

the default visual presentation, but it will be available for use within alternative presentations of the graph that are created by SAS Graphics Accelerator:

```
xaxis label='Only visible in alternative presentations' display=(nolabel);
```

STEP 7: SPECIFY LEGEND LABELS

It is a best practice to include a legend in all graphs that contain multiple layers,for example, a graph that was created by specifying two or more SERIES statements within the SGPLOT procedure. This practice will help all users understand your graphs. However, there might be situations in which it is not practical to display a legend in the default visual presentation of a graph, or it is reasonable to expect users with typical vision to derive the content presented in each layer from the surrounding context.

In that situation, you might choose to use the NOAUTOLEGEND option to remove the legend from the default visual presentation. However, remember that users with disabilities who access alternative presentations of that graph might not have immediate access to the surrounding context. They need access to a descriptive label for each layer within a multi-layer graph when they "view" an alternative presentation generated by SAS Graphics Accelerator. Legend labels serve this purpose.

ODS Graphics will always provide a legend label for each layer of a multi-layer graph within the accessibility metadata used by SAS Graphics Accelerator. The values of the legend labels are computed using the same rules of precedence that are used within visible legends that appear in the default visual presentation. Before you remove a legend using the NOAUTOLEGEND option, make sure the automatically derived legend labels make sense when they are used in alternative presentations, and use the LEGENDLABEL option to override the default labels if necessary.

The following code specifies custom legend labels:

```
proc sgplot data=sashelp.class description='Mean weight and height by age';
    vline age / response=weight stat=mean
          lineattrs=(color=blue pattern=longdash)
          legendlabel='Mean Weight';
    vline age / response=height stat=mean
          lineattrs=(color=red pattern=dash)
          legendlabel='Mean Height';
run;
```

CONCLUSION

SAS 9.4M5 ODS Graphics and SAS Graphics Accelerator deliver the most advanced data visualization accessibility available in the market. Lay the foundation for accessibility by using the ODS HTML5 destination, the Daisy style, the ACCESSIBLE_GRAPH option, and the SVG output format. Include an accessibility statement in your output that provides a link to the SAS Graphics Accelerator product page on support.sas.com. Avoid using color alone to convey meaning. Use plain language in variable values. Specify a description, axis labels, and legend labels. Print the handy one-page checklist in Appendix A and refer to Creating Accessible SAS 9.4 Output Using ODS and ODS Graphics for more information.

CONTACT INFORMATION

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

Ed Summers
SAS Institute Inc.
100 SAS Campus Drive
Cary, NC 27513
ed.summers@sas.com

Julianna Langston
SAS Institute Inc.
100 SAS Campus Drive
Cary, NC 27513
julianna.langston@sas.com

Dan Heath
SAS Institute Inc.
100 SAS Campus Drive
Cary, NC 27513
dan.heath@sas.com

APPENDIX A: CHECKLIST FOR CREATING ACCESSIBLE GRAPHS

1. Use the ODS HTML5 destination with STYLE=Daisy and ACCESSIBLE_GRAPH. Keep accessibility in mind if you override style elements or attributes. Include an accessibility statement in your output that provides a link to the SAS Graphics Accelerator product page.

2. Use the ODS GRAPHICS statement and the OUTPUTFMT option to select the SVG output format.

3. Do not use color alone to convey meaning. Use the ODS GRAPHICS statement to Enable data tips using the IMAGEMAP option and enable line patterns using the ATTRPRIORITY=NONE option. Use the FILLPATTERN option within the ODS Statistical Graphics procedures to enable fill patterns. If you explicitly specify color within a graph make sure you also specify markers, line patterns, or fill patterns.

4. Specify a description using the DESCRIPTION option in the ODS Statistical Graphics procedures.

5. Use the FORMAT procedure to specify clear, plain language for variable values.

6. Specify permanent labels for all variables using the LABEL statement in a DATA step so that the ODS Statistical Graphics procedures will have access to reasonable default values for axis labels. Override the reasonable defaults as needed using the LABEL, XAXIS, or YAXIS statements within a procedure.

7. Specify legend labels for each layer of multi-layer graphs using the LEGENDLABEL option.

Cut and paste this sample code as needed:

```
ods html5 style=Daisy accessible_graph;
ods escapechar="^";
proc odstext;
  p "Accessibility: This page contains data visualizations that can be
viewed in alternative formats. Install ^{style
[url='https://support.sas.com/software/products/graphics-
accelerator/index.html'] SAS Graphics Accelerator} to generate text
descriptions, view underlying data in a tabular format, or interactively
explore data visualizations using sound. ";
run;
ods graphics / outputfmt=svg imagemap attrpriority=NONE;
proc format;
  value $sex 'F'='Female' 'M'='Male';
run;
proc sgplot data=sashelp.class description='Students by sex';
  format sex $sex.;
  vbar sex;
run;
proc sgplot data=sashelp.class
description='Meagn weight by age grouped by sex';
   format sex $sex.;
   vbar age / response=weight stat=mean group=sex
              groupdisplay=cluster fillpattern;
  yaxis label='Mean weight grouped by sex';
run;
proc sgplot data=sashelp.class description='Mean weight and height by age';
   vline age / response=weight stat=mean
         lineattrs=(color=blue pattern=longdash)
         legendlabel='Mean Weight';
   vline age / response=height stat=mean
         lineattrs=(color=red pattern=dash)
         legendlabel='Mean Height';
run;
```