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Next Level Reporting: ODS and Open Source

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ABSTRACT

This document describes techniques used to get started with the Output Delivery System such as an introduction to the Output Delivery System basics. Also discussed include automating and making the most out of your ODS destinations. This document will also highlight the dynamic capabilities when using ODS. The document will further drill down on the popular ODS Excel destination and discuss highlights and limitations of this destination. Finally, this document will discuss open-source integration in SAS and Viya platforms and how this can be used to take your reporting to the next level. Concepts will focus on techniques geared to the data analyst and SAS programmer.

INTRODUCTION

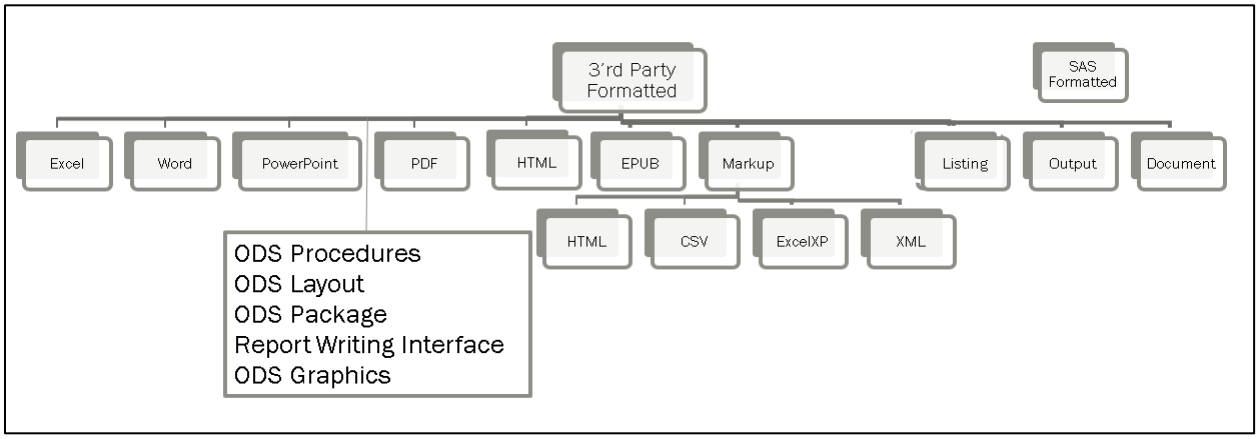
The Output Delivery System is a great way to automate your reporting by generating output in some of the industry's most used file formats. Along with the ability to generate files in the various formats, ODS can generate output data sets from most procedures. Both the SAS and Viya platforms provide the ability to use open-source clients to enhance your reporting. This paper was created with the beginner ODS user in mind; however, it applies to all levels of SAS programmers and analysts.

THE ODS DESTINATIONS AND ECOSYSTEM

The Output Delivery System is fully integrated in the SAS system. Programming clients such as SAS Studio, Enterprise Guide, and the Display Manager System (DMS) all use ODS as the default for output generation. Also, most procedures have underlying table templates that control the default formatting of the output. In this section, we will explore the ODS destinations along with ODS procedures and some of the other ODS statements. As pervasive as ODS is within the SAS System it is also very flexible and customizable. We will do a deep dive on a few of the ODS destinations, ODS procedures, and other statements in the ODS ecosystem.

DISCOVERING ODS DESTINATIONS

The Output Delivery System can generate output in many of the industry's most widely used file formats. This includes HTML, Excel, Word, PDF, PowerPoint, XML, and various other formats. The ODS destinations are very diverse for instance some formats such as HTML are great for sharing, while others such as PDF are better when printed output is required. Display 1, list a subset of the ODS destinations and various other members of the ODS ecosystem.



Display 1. ODS Destinations and Procedures

ODS PROCEDURES AND ECOSYSTEM MEMBERS

There are several procedures added within the ODS ecosystem, however none is more important than the TEMPLATE procedure. The TEMPLATE procedure is responsible for creating and modifying styles, tables, tagsets, and statistical graphics templates. In addition, the TEMPLATE procedure is also responsible for managing item stores. The complete list of procedures in the ODS ecosystem includes:

- PROC ODSTEXT/ODSLIST
- PROC DOCUMENT
- PROC ODSTABLE
- PROC TEMPLATE

The ODSTEXT and ODSLIST procedures create lists and paragraphs and were created with the PowerPoint destination in mind, however, they have become a best practice for adding text with the formatted destinations. Other procedures include the DOCUMENT procedure which manages ODS documents by copying, moving, renaming, deleting, and replaying objects of an ODS document. The ODSTABLE procedure is a very powerful reporting procedure that takes most of its features from table templates while making the syntax more user-friendly. Additional ecosystem members are detailed in the following sections.

The ODS Layout Statement

ODS Layout provides the ability to place objects on a page. Using ODS Layout within the ODS destinations is a great way to add dashboards or generate complex output. There are two types of layouts which are gridded and absolute. A gridded layout enables you to arrange output dynamically in a two-dimensional grid structure and handles the spacing. An absolute layout provides explicit positioning using X and Y coordinates. The following ODS Layout statement provides instructions to generate a gridded layout on the page using two rows and two columns. Each object whether a procedure, graph, or DATA step is added within the ODS REGION statement to be included within the layout. Absolute layouts are available with the PDF and Printer destinations only.

```
ods layout gridded columns=2 rows=2;
ods region
  <procedure>
ods region
  <procedure>
  …
ods layout end;
```

The Report Writing Interface

The Report Writing Interface (RWI) provides the ability to generate complex reports such as a patient profile. Reports that are often difficult to generate using one of the reporting procedures are less complicated using RWI. The Report Writing Interface uses object-oriented syntax to build reports. The first step when building a report with RWI is to create an object which is done using the DECLARE statement. Once an object is generated, you can use the documented methods to add the desired functionality to the report. Some of the popular groups of methods include the table, layout, and a general group of methods. The following RWI step uses the DECLARE statement and creates the object OBJ(). The method FORMAT_TEXT is then used to add text.

```
data _null_;
  declare odsout obj();
  obj.format_text(data:"Some text");
run;
```

REPORTING USING ODS DESTINATION AND PROCEDURES

This section samples selected ODS destinations that demonstrate next-level reporting capabilities. Some of the strengths include being accessible, secure, stylistic, and customizable. We will look at the strengths of some of the destinations such as HTML, Excel, PDF, and PowerPoint combined with other items within the ODS ecosystem.

NEXT LEVEL HTML

The HTML format is great for providing information that can be shared regardless of the device or operating system. One of the greatest features of the HTML format is its' accessibility support. ODS HTML5 provides accessible output that includes captions for tables, and scope tags for headers which are used by assistive technologies. The HTML5 destination also has support for accessible headers using the ODSTEXT procedure. A major benefit of the HTML5 destination is that graphics are embedded within the web page as a default. The HTML5 destination is very flexible and customizable and provide many methods of enhancing output. Some items include adding sticky headers, including a Viewport meta tag, creating dashboards using ODS Layout. This section will discuss a few of these enhancements to the file.

Adding Sticky Headers

A technique for freezing table headers can be done using a JavaScript library or Cascading Style Sheets using the stylesheet property Sticky-header. This style property locks the column headers while scrolling long tables. A simple method of providing this style property to the HTML file is using the HEADTEXT= ODS HTML5 option. When the statement has been added, the value is added to the header section of the HTML file.

```
headtext="<style> thead {position: sticky;top:0 }</style>";
```

Using Viewport to Control Display

Controlling the display of HTML on mobile devices can be done using the Viewport meta tag. This tag can be added using the METATEXT= option on the ODS HTML/HTML5 statements. The NAME= parameter specifies the value Viewport and the CONTENT= specifies the dimension of the device. Specifying the viewport allows the display to fit nicely depending on the device such as an iPhone. The METATEXT= ODS HTML5 can also add other content such as the content security policy which is more generally added to headers.

```
metatext='name="viewport" content="width=device-width, initial-scale=1"';
```

Accessibility Features

Accessibility is the strength of the HTML5 format. Accessible headers can be added to HTML files using the PROC ODSTEXT procedure. The H1-H6 statements within the ODSTEXT procedure are used to add headers which are expected by assistive technologies. There is also the SAS Graphics Accelerator which can be used with HTML5 that enables you to explore the graph and data within the graph in various interactive ways. Using the ACCESSIBLEGRAPH system option enables the graph to be read, interpreted and amplified by the SAS Graphics Accelerator. The following ODSTEXT procedure demonstrates generating accessible headers with the ODS HTML5 destination and creating alternate text with the PROC SGPLOT procedure.

```
proc odstext;
   h1 "This header uses the H1 tag";
   h2 "This header uses the H2 tag";
```

```
   h3 "This header uses the h3 tag";
run;
```

HTML

```
<h1 class="heading1">This header uses the H1 tag</h1>
<h2 class="heading2">This header uses the H2 tag</h2>
<h3 class="heading3">This header uses the h3 tag</h3>

proc sgplot data=sashelp.cars
  des="Make of Cars";
  vbar make;
run;
```

HTML

```
<img alt="Make of Cars" src="SGPlot1.png" style=" height: 480px; width:
640px;" border="0" class="c">
```

Example Study of Blood Pressure Versus Weight Using ODS HTML5

The following example highlights some of the previously discussed features in this section and presents the results of a study of subjects with high blood pressure and weight. The HTML report generates sticky headers, adds a viewport meta tag, generates accessible headers using the ODSTEXT procedure, and uses the CALL DEFINE statement to add styles to the row and hyperlinks to highlight when the blood pressure is high, and the weight status is overweight.

In this example:

1. The HEADTEXT= ODS HTML5 option is used to add the sticky header style.
2. The METATEXT= option adds the Viewport for the mobile browser.
3. PROC ODSTEXT is used to add accessible headers with the H1 statement.
4. The CALL DEFINE statement is adds a row color and hyperlinks to a web page based on the value of the variable BP_STATUS and WEIGHT_STATUS.

Example 1

```
ods html5 path="c:\temp" file="temp.html"
  headtext="<style> thead {position: sticky;top:0 }</style>"  ❶
  metatext='name="viewport" content="width=device-width, initial-scale=1"'; ❷

proc odstext; ❸
  h1 "Study of Blood Pressure Status" / style=systemtitle[just=c];
run;

proc report data=sashelp.heart(obs=100);
column Sex diastolic Systolic height weight BP_Status weight_status;
   compute weight_status;
    if bp_status="High" and Weight_status="Overweight" then ❹
      do;
          call define(_row_,"style","style={background=#f0f5f5}");
          call define(_col_,"url","https://www.cdc.gov/
                   healthyweight/tools/index.html");
       end;
    endcomp;
run;
ods html5 close;
```

Study of Obesity and Blood Pressure Status

Sex	Diastolic	Systolic	Height	Weight	Blood Pressure Status	Weight Status
Female	78	124	62.5	140	Normal	Overweight
Female	92	144	59.75	194	High	Overweight
Female	90	170	62.25	132	High	Overweight
Female	80	128	65.75	158	Normal	Overweight
Male	76	110	66	156	Optimal	Overweight
Female	92	176	61.75	131	High	Overweight
Female	80	112	64.75	136	Normal	Overweight
Male	80	114	65.5	130	Normal	Normal
Male	68	132	71	194	Normal	Overweight
Male	78	124	62.5	129	Normal	Normal
Male	76	128	66.25	179	Normal	Overweight
Male	68	108	64.25	151	Optimal	Overweight

Output 1. HTML output on desktop and mobile client

NEXT LEVEL PDF

The Portable Document Format (PDF) is one of the most widely accepted document formats. The PDF format also has seamless compatibility across devices and operating systems. Accessibility is the strength of the PDF format which is inherited by the ODS PDF destination. In addition to being accessible, the PDF format is also secure and requires special software to edit the file. The PDF format is also great when printed output is required. This section will discuss why the ODS PDF destination is a next-level reporting tool.

Accessibility and ODS PDF

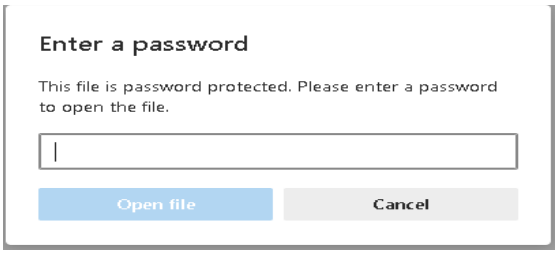
There are many accessibility features added when the ACCESSIBILE option is placed on the ODS PDF statement. When the ACCESSIBLE option is added, features such as tagged PDFs are generated which are used by assistive technologies. The PROC ODSTEXT procedure can also be used to generate accessible headers for this destination using the H1-H6 statements to add text.

```
ODS PDF file="my report.pdf" ACCESSIBLE;
```

Password Protecting PDF Files

Security can be implemented for PDF files using the system options PDFPASSWORD= and PDFSECURITY=. When these options are specified as below, the PDF file is encrypted and requires a password before opening files generated using the ODS PDF destination. The options statement shown in display 2, prompts users when opening the PDF file for the password.

```
options pdfsecurity=high fpw=(open=xxx);
ODS PDF file="report.pdf";
```



Display 2. Prompt for the Password for PDF Files

Generating Dynamic Page Control

The ODS PDF destination provides dynamic page control using the STARTPAGE= ODS PDF option. This option is responsible for controlling which page tables and graphics are placed. Valid values for this option are YES, NO, NOW, NEVER and BYGROUP. When the value NO is specified, the output is added to the same page when it is possible to fit. The value YES is the default and places each table or graph on a separate page. The option is added to the ODS PDF statement as displayed on the following ODS PDF statement.

```
ODS PDF file="report.pdf" startpage=no;
```

ODS Layout- Absolute

The PDF/Printer destinations are the only destinations that provide the ability to generate absolute layouts. This allows you to position table, graph, or text exactly on a page based on the X and Y coordinates specified. This provides the PDF destination more flexibility to generate complex reports. The X and Y coordinates are specified ODS REGION statement. The following layout within the PDF destination specifies the height and width of the layout along with ODS REGION statements which specifies the coordinates for the placement of the object.

```
ods layout absolute width=8.5in height=11in;
ods region x=1.5in y=2in;
 proc …;
ods region x=2.5.y=4in;
 proc …;
ods layout end;
```

Example Clinical Trial Report of Blood Pressure and Cholesterol Using ODS PDF

The following example generates a sample summary of a clinical study that reviews cholesterol and blood pressure. The Report Writing Interface builds the summary of the report first followed by a table with detailed data, a graph and further text describing the results.

In this example:

1. The ODS PDF statement is added using the ACCESSIBLE option.
2. The ODS Report Writing Interface is used to add a summary prior to the detail.
3. ODS Layout is used with an absolute layout to place a detailed table, graphics, and summary on the page.
4. The ODS REGION statement is added for the PROC REPORT and the PROC SGPLOT procedures.

Example 2

```
options nodate nonumber;
ods pdf file="c:\temp\trial.pdf" ACCESSIBLE startpage=no; ❶
options nocenter;
```

```
 data _null_;  ❷
    declare odsout obj();
       obj.format_text(data:"JNJ-56021927 (apalutamide)");
       obj.format_text(data:"Clinical Study Report ARN-509-003",
            style_attr:"just=r width=8.5in");
       obj.line();
       obj.format_text(data:"Aragon Pharmaceuticals, Inc*",
            style_attr:"just=c fontsize=14pt width=8.5in");
       obj.format_text(data:" ",row_span:3);
       obj.format_text(data:"Clinical Study Report",
            style_attr:"just=c fontsize=10pt width=8.5in");
       obj.line();
       obj.format_text(data:"A Multicenter, Randomized, Double-Blind,
         Placebo-Controlled, Phase III Study",
            style_attr:"just=c fontsize=12pt width=8.5in");
       obj.format_text(data:" ");
       obj.format_text(data:"Selective Cholesterol Targeting with ARN
         509",style_attr:"just=c fontsize=10pt width=8.5in");
       obj.line();
       obj.format_text(data:" ");
       obj.format_text(data:"Protocol ARN-509-003; Phase 3",
             style_attr:"just=c fontsize=10pt width=8.5in");
run;

  ods layout absolute width=8.5in height=11in; ❸
  ods region x=0in y=.3in;  ❹
  proc report data=sashelp.heart(where=(sex="Male"));
  column sex chol_status BP_Status systolic cholesterol;
  define sex / group;
  define bp_status / group;
  define chol_status / group;
  define systolic / mean;
  define cholesterol / mean;
  run;

  ods region x=3.5in y=.5.5in; ❹
  ods graphics / height=1.5in width=3in;
    proc sgplot data=sashelp.heart;
    vbar bp_status / group=sex response=systolic stat=mean;
  run;

  proc odstext;
     p "The researchers used a 3-sample randomization analysis of
        participants who were registered." /style={fontsize=9pt};
     p "There were three groups in the analysis:" / style={fontsize=9pt
        fontweight=bold};
     list / style={liststyletype="disc" fontsize=9pt};
          item "130 people had high cholesterol (LDL-C)";
          item "150 people had elevated systolic blood pressure (SBP)";
          item "170 people had coronary heart disease";

    end;
 run;

 ods layout end;
 ods pdf close;
```

JNJ-56021927 (apalutamide)

Clinical Study Report ARI

Aragon Pharmaceuticals, Inc*

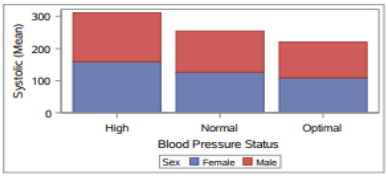
Clinical Study Report

A Multicenter, Randomized, Double-Blind, Placebo-Controlled, Phase III Study

Selective Cholesterol Targeting with ARN 509

Protocol ARN-509-003; Phase 3

Sex	Cholesterol Status	Blood Pressure Status	Systolic	Cholesterol
Male	Borderline	High	150.46324	219.62745
		Normal	127.61	218.6475
		Optimal	111.19149	220.1383
	Desirable	High	151.75424	178.72458
		Normal	127.42804	178.05904
		Optimal	111.21505	173.95699
	High	High	153.75243	273.83738
		Normal	128.02439	267.43554
		Optimal	110.63415	269.86585



The researchers used a 3-sample randomization analysis of participants who were registered.

There were three groups in the analysis:

- 130 people had high cholesterol (LDL-C)
- 150 people had elevated systolic blood pressure (SBP)
- 170 people had coronary heart disease

Output 2. Clinical Trials Summary Created using ODS PDF

NEXT LEVEL EXCEL

The ODS Excel destination generates output in the Microsoft Office Open Office Document format (.xlsx). The Excel output is unique compared to other file formats as this tool allows for further analysis after handing off the worksheet. Excel files can be created using SAS in a variety of ways such as PROC EXPORT and the ODS Excel destination. The ODS Excel destination provides features such as the ability to add options, formulas, formats, images, placement of output, and various other features. Styles can be added with the ODS Excel destination using either PROC TEMPLATE or Cascading Style Sheets. In this section, we will discuss these topics further.

ODS Excel Options

There are over 50 options available for use with the ODS Excel destination that allow modifications to most parts of the workbook or worksheet. These options control most of the frequently modified features of an Excel worksheet or workbook such as the page setup options, freezing rows and columns, adding filters, and various other modifications. The options are added using the Options, option on the ODS Excel statement. The following statement displays the basic syntax for supplying options.

```
ods excel options(options-1,options-2..)
```

Adding Excel Formats and Formulas

The ability to add formulas provides a dynamic component that allows the ability to further analyze the data with over 500 Excel formulas to choose from. The ODS Excel destination adds formulas using the TAGATTR= style attribute which passes the formula directly to Excel without any validation. The following syntax adds a formula using the TAGATTR= style attribute on the define statement of PROC REPORT.

```
Define column / style(column)={tagattr="formula:=SUM(RC[-4]:RC[-3]")
```

Excel formats can be added using either SAS formatting which gets mapped to the equivalent Excel format or using Excel forming applying the TAGATTR= style attribute as demonstrated in the following

statement. The DEFINE statement from the REPORT procedure is used to apply the ACCOUNTING Excel format to the field column.

Define `column / style(column)={tagattr="format:Accounting")`

Adding Graphics and Images to the Worksheet

Images can be added to the worksheet using the GSLIDE procedure or by adding the IMAGE method using the Report Writing Interface**.** Neither of these methods allows for specific image placement or sizing. The ODS Excel destination does support the BACKGROUNDIMAGE= attribute for the worksheet. The following statement adds an image using RWI and the IMAGE method. Graphics can be added to the ODS Excel destination using either ODS Graphics or SAS/Graph.

```
data _null_;
  dcl odsout obj();
  obj.image( file: "Heart.png" description="Heart Health")
run;
```

Example Study of Heart Health and Weight Using ODS Excel

The following example uses ODS Excel options to add features to the Excel worksheet. Also, the Report Writing Interface is used to add a summary table to the beginning of the worksheet by adding formulas. The BMI is calculated using a formula to determine when the CDC determination has been documented.

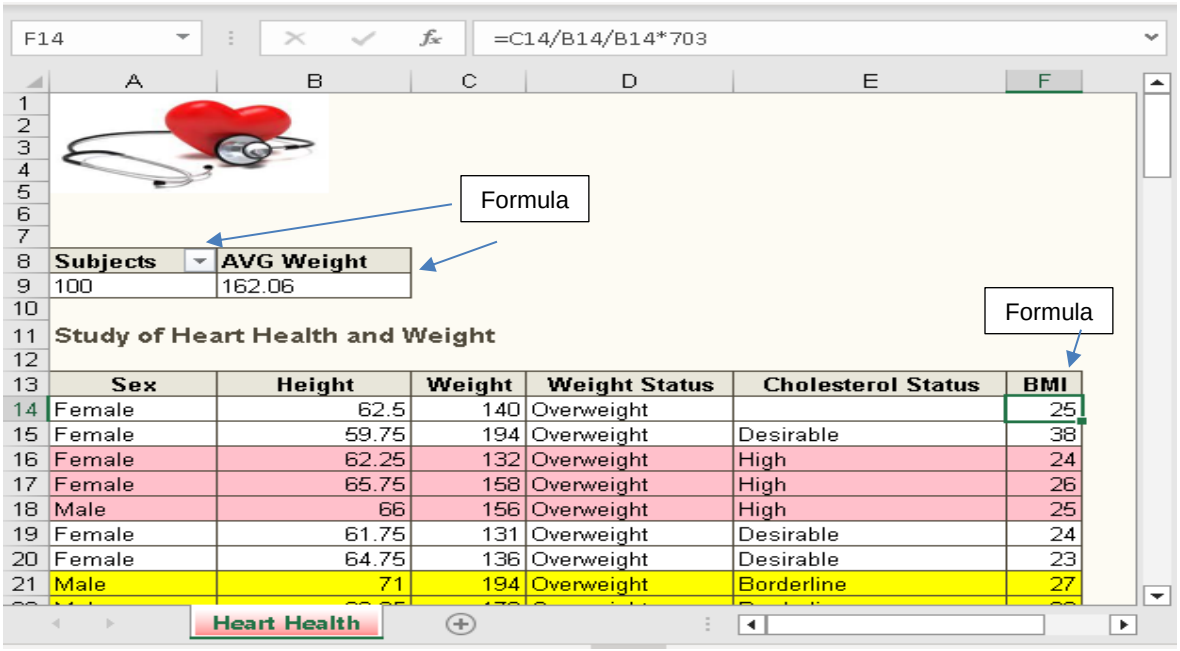
In this example:

1. Options are added to embed the title, freeze the column headers, add filters to the first 3 columns, add a tab name and color, and finally prevent ODS Excel from adding content to a new sheet.
2. The Report Writing Interface is used with the IMAGE method to add an image to the worksheet along with the TABLE method which adds a summary table with formulas.
3. A new computed column BMI is added using the TAGATTR= attribute with the FORMULA parameter.
4. Styles were added to the background of various rows using the CALL DEFINE statement within the compute block of PROC REPORT.

Example 3

```
title "Study of Heart Health and Weight ";
ods excel file="c:\temp\heart.xlsx" options(embedded_titles="yes" ❶
                    autofilter="1" sheet_name="Heart Health"
                    sheet_interval="none" tab_color="red") style=analysis;

  data _null_;  ❷
    declare odsout obj();
    obj.image(file:"c:\temp\heart.jpg");
    obj.table_start();
    obj.head_start();
    obj.row_start();
         obj.format_cell(data:"Subjects");
         obj.format_cell(data:"AVG Weight");
    obj.row_end();
    obj.head_end();
    obj.row_start();
         obj.format_cell(data:"=count(c:c)");
         obj.format_cell(data:"=average(c:c)");
    obj.row_end();
    obj.table_end(); run;
```

```
title "Study of Heart Health and Weight ";
proc report data=sashelp.heart(obs=100);
where weight_status="Overweight";
column sex height weight weight_status chol_status BMI;
define BMI / computed style(column)={tagattr="formula:=RC[-3]/RC[-4]/RC[-
4]*703"}; ❸

compute chol_status; ❹
   if weight_status="Overweight" and chol_status="High" then
      call define(_row_,"style","style=[background=pink]");
   else if weight_status="Overweight" and chol_status="Borderline" then
      call define(_row_,"s tyle","style=[background=yellow]");
endcomp;
run;
ods excel close;
```



Output 3. Sample Study of Heart Health using ODS Excel

PRESENTATION OF HEART HEALTH USING ODS POWERPOINT

The PowerPoint format (.pptx) is a good way to present and disseminate information in the most widely accepted format for presentations. One of the reasons is that PowerPoint allows for visuals that are very engaging and will last long after discussions within a meeting. ODS provides the ability to generate slides directly from a DATA step or procedure. The styles that work with the ODS PowerPoint destination are the PowerPointLight and the PowerPointDark both of which are shipped with SAS. The PowerPoint destination takes advantage of many of the features of PowerPoint such as the ability to add options to do such things as add background images or colors to each slide, add transitions and effects, and gradients. The PowerPoint destination can also be used with ODS Layout to place graphics and tables on a slide using gridded layouts.

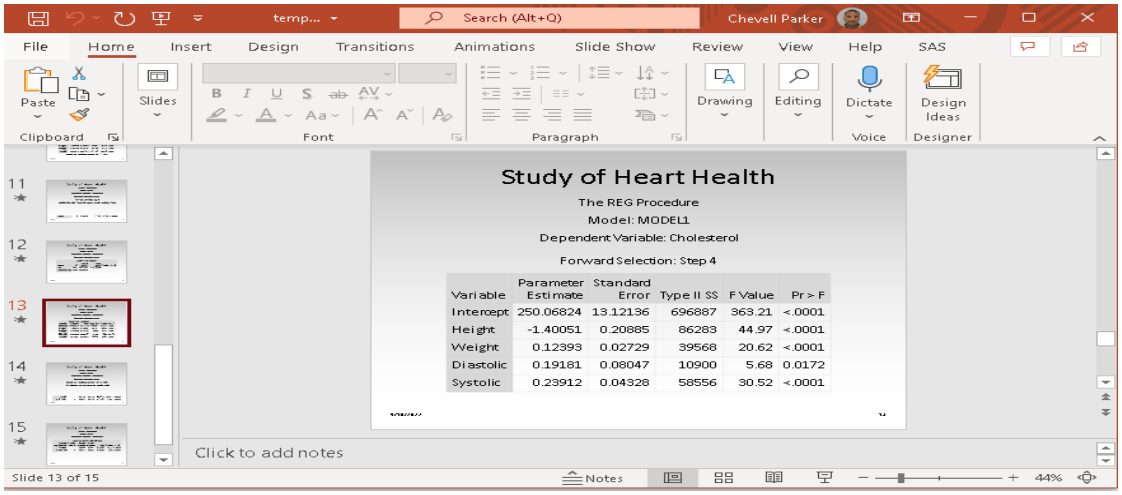
In this example:

1. The transition= option is set and adds a transition between slides, while the effect option is set to an effect.

2. The backgroundimage= option is added with a gradient color which has two separate colors.
3. The REG procedure models cholesterol with the height and weight along with the diastolic and systolic variables with the selection=forward.

Example 4

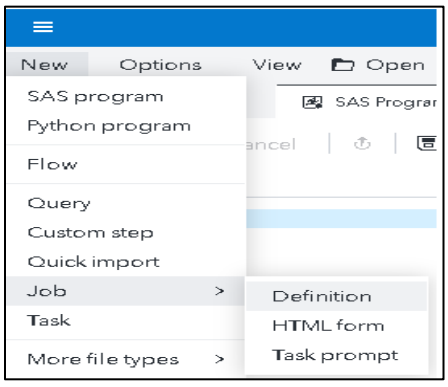
```
ods powerpoint file="temp.pptx"
   options(transition="push" effect_option="from_left"    ❶
           backgroundimage="linear-gradient(90deg ,#c0c0c0, #FFFFFF)"); ❷

title "Study of Heart Health";
proc reg data=sashelp.heart; ❸
model cholesterol=height Weight diastolic systolic
      / selection=forward;
run;
quit;
ods powerpoint close;
```



Output 4. Presentation of Heart Health using ODS PowerPoint

GENERATING DYNAMIC CONTENT USING ODS AND VIYA

You can generate dynamic front ends for your programs by creating a Viya job. A SAS Viya job consists of a program and its definition. The job definition includes information such as the job name, the author, and the creation date and time. You can also create a user interface for the job which can be an HTML form or task prompt which gives the user the ability to do such things as create a selection list that can pass the values as macro variables to the program.

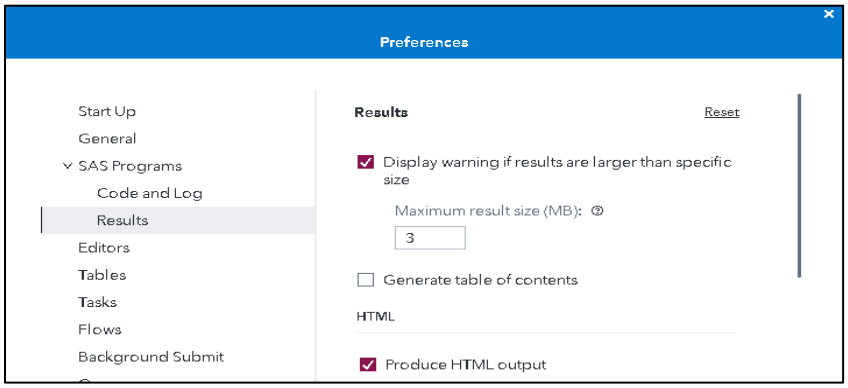


Display 3. Creating a Viya Job

SELECTING ODS FORMATS USING SAS STUDIO

SAS Studio is a web-based client and is one of the clients that is used as a front end to SAS Viya. The default output format for SAS Studio is HTML5 and is displayed on the results tab by default. In addition to the HTML5 output generated, other ODS output formats may be selected such as PDF, Word, Excel, RTF, and PowerPoint. To select other formats other than HTML5, simply navigate to the preferences window and select Results. This will display the output formats available that you can select.

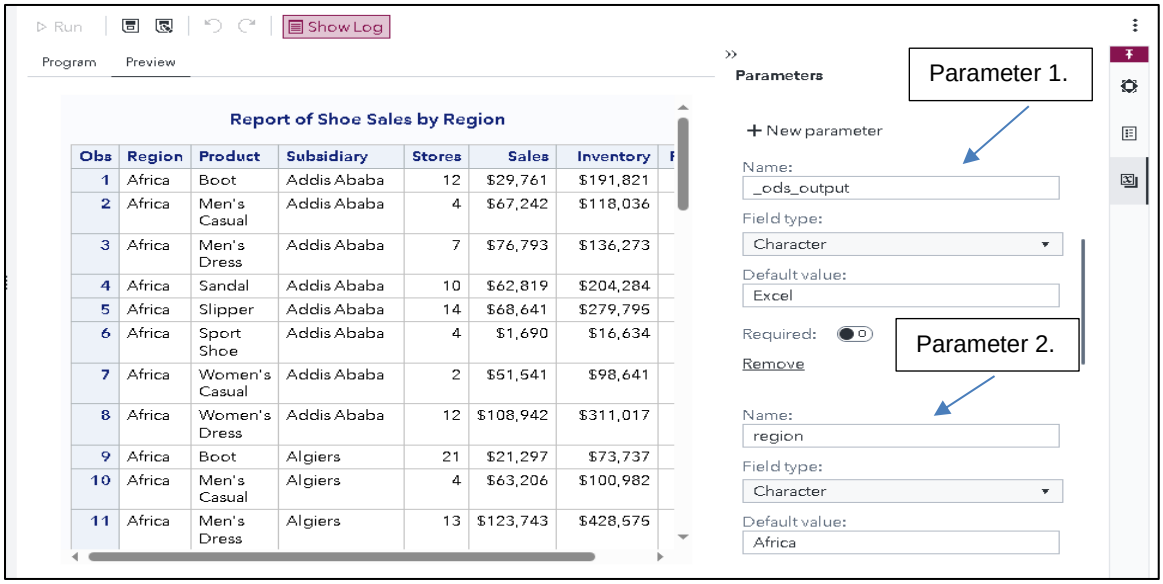
Options→ Preferences-> Results



Display 4. SAS Studio Preferences Window

Adding Job Parameters Using SAS Studio

In addition to going to the preferences window and selecting the desired file formats, the ODS destinations can also be selected by passing the desired ODS destination as a parameter. Various built-in parameters can be chosen such as the _ODS_OUTPUT parameter which provides the ability to add the ODS destination. User-defined parameters can also be added which are passed to the program as a macro variable. To add parameters, open the parameters pane as displayed in Display 5, and enter the name of the parameter followed by the value. Display 5 also displays adding the _ODS_OUTPUT parameter with the Excel destination along with the user defined parameter Region which was used to subset the data which was added as a macro variable on the WHERE statement.



Display 5. Adding Job Parameters using Viya Jobs

Adding a Link to Include Other ODS Formats

The previous examples of selecting output formats can be further enhanced to allow the user to view the destination of choice by selecting a link on the page. In the following example, the ODS Document destination was used to create a document from the PROC PRINT output. The DOCUMENT procedure replays the content of the ODS Document along with the Filename statement using the FILESRVC access method and the ODS PDF destination to SAS Content in the Viya platform. The user can then select whether to view the page as an HTML file or PDF.

Example 5.

1. An ODS Document is created with the output of the PRINT procedure.
2. The FILENAME statement with the FILESRVC access method is used to store the PDF file in SAS Content.
3. A hyperlink is added for this PDF file which is stored as a content object.
4. The link to the PDF file is added via the TEXT= option of the ODS HTML5 statement.

```
ods document name=test; ❶
proc print data=sashelp.shoes;
run;
ods document close;

filename f_pdf filesrvc parenturi="&SYS_JES_JOB_URI" name='shoes.pdf' ❷
                      contenttype='application/pdf';

ods pdf file=f_pdf style=HTMLBlue;
proc document name=test;
  replay;
quit;
ods pdf close;

%let PDF_LINK=%bquote(<a href=""&_FILESRVC_F_PDF_URI/content""  ❸
target=""_Self""> PDF</a>);

filename f_htm filesrvc parenturi="&SYS_JES_JOB_URI" name='_webout.htm'; ❹
ods html5 file=f_htm text="<span>^{style systemtitle &PDF_LINK}</span>";

proc document name=test;
replay;
run;
quit;

ods html5 close;
```

PDF

Obs	Region	Product	Subsidiary	Stores	Sales	Inventory	Returns
1	Africa	Boot	Addis Ababa	12	$29,761	$191,821	$769
2	Africa	Men's Casual	Addis Ababa	4	$67,242	$118,036	$2,284
3	Africa	Men's Dress	Addis Ababa	7	$76,793	$136,273	$2,433
4	Africa	Sandal	Addis Ababa	10	$62,819	$204,284	$1,861
5	Africa	Slipper	Addis Ababa	14	$68,641	$279,795	$1,771

Output 5. Adding a link to the PDF output on the page

USING OPEN SOURCE TO ENHANCE REPORTING

The Output Delivery System may fulfill most of your reporting needs with its destinations and ecosystem members, however, there are times when you simply need an additional feature that may not be available. This is when extending the software using open-source technologies allows you to bridge that gap. This section will discuss open-source technologies such as the Python language and how they can be used and easily integrated into the SAS and Viya platforms to enhance your reporting needs. There are many methods of integrating open-source technologies such as PROC LUA, PROC GROOVY, PROC IML, and the DATA Step Java Object just to name a few. This paper will concentrate on Python language.

PYTHON FOR SAS PROGRAMMERS

Python is a high-level programming language used for a wide variety of applications such as automation, web development, and data analysis. The Python language has various libraries that can read and write files in many of the industry's most common formats. The XLSX format is a widely popular file format for data scientists and can be created and enhanced using several Python libraries such as Pandas, Openpyxl, XlsxWriter in addition to some others. Additional libraries such as PyPDF2 provide the capability of reading and modifying PDF files. In this section, we will demonstrate how Python can be used to create and enhance formats such as XLSX and PDF within SAS and Viya.

Installing Python and Packages

The Python application must first be installed to take advantage of the features discussed in this section. To install Python, you will need to decide on the distribution to use such as Anaconda or Python.org. Once Python is installed, you will then want to install the desired packages. In this section, we will explore the Pandas, Openpyxl, and XlsxWriter libraries which have the capability of working with XLSX files. We will also explore the PyPDF2 which provides the ability to create and modify PDF files.

To install Python packages, use either the PIP or Conda commands from the command prompt with the name of the packages to install. If you are using Viya 4 and installing and configuring packages to be used with SAS Studio, the SAS Configurator for Open Source which can be used to install and configure Python with Viya 4 as well as Python and R packages.

- Pip install OpenPyXL XlsxWriter PyPDF2

Pandas Python Package

The Pandas library is used for data manipulation and analysis. It provides data structures for storing and manipulating large tables. It can read, filter, and rearrange data and output it into a variety of formats. The Pandas package complements the integration features in SAS some which were modeled after the Pandas library. Table 1. displays a subset of the various file formats which can be read and written using the Pandas library. Because SAS data sets and Pandas DataFrames can be moved between the applications, you can see how this will allow us to extend the software.

.

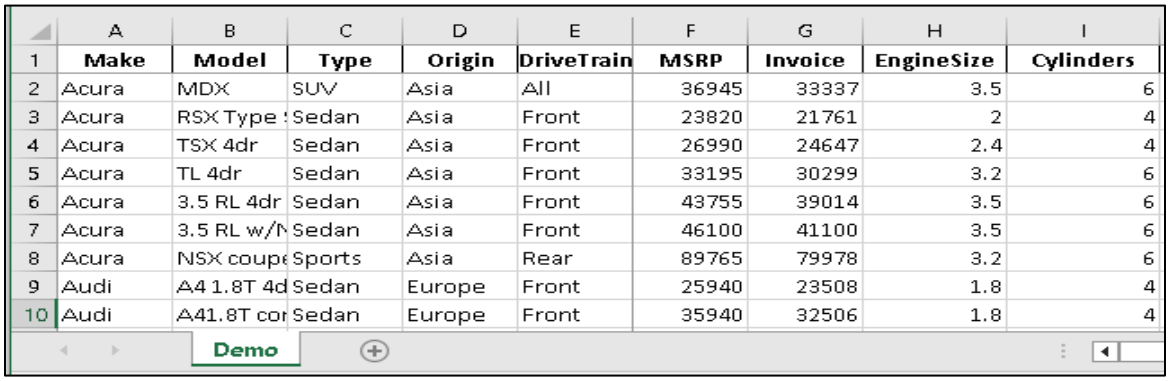
Format	Read	Write
SAS	Read_SAS	csv/excel/xml
EXCEL	Read_excel	To_Excel
JSON	Read_Json	To_json
XML	Read_xml	To_xml
Parquet	Read_parquet	To_Parquet
SQL	Read_SQL	To_SQL
HTML	Read_html	To_html

Table 1. Subset of Pandas I/O Methods

The following example imports the Panda's library using the READ_CSV method and creates a Python dataFrame from the cars.csv file. The TO_EXCEL method exports the Pandas DataFrame to an XLSX file adding the FREEZE_PANES=, the SHEET_NAME=, and the INDEX= options.

Example 6.

```
import pandas as pd
df = pd.read_csv('https://support.sas.com/documentation/'
                 'onlinedoc/viya/exampledatasets/cars.csv')
wb = df.to_excel('c:/temp/cars.xlsx',
                 sheet_name='Demo',
                 freeze_panes=(1,5),
                 index=False)
```



	A	B	C	D	E	F	G	H	I
1	Make	Model	Type	Origin	DriveTrain	MSRP	Invoice	EngineSize	Cylinders
2	Acura	MDX	SUV	Asia	All	36945	33337	3.5	6
3	Acura	RSX Type	Sedan	Asia	Front	23820	21761	2	4
4	Acura	TSX 4dr	Sedan	Asia	Front	26990	24647	2.4	4
5	Acura	TL 4dr	Sedan	Asia	Front	33195	30299	3.2	6
6	Acura	3.5 RL 4dr	Sedan	Asia	Front	43755	39014	3.5	6
7	Acura	3.5 RL w/N	Sedan	Asia	Front	46100	41100	3.5	6
8	Acura	NSX coupe	Sports	Asia	Rear	89765	79978	3.2	6
9	Audi	A4 1.8T 4d	Sedan	Europe	Front	25940	23508	1.8	4
10	Audi	A41.8T cor	Sedan	Europe	Front	35940	32506	1.8	4

Demo

Output 6. Output from Pandas Export

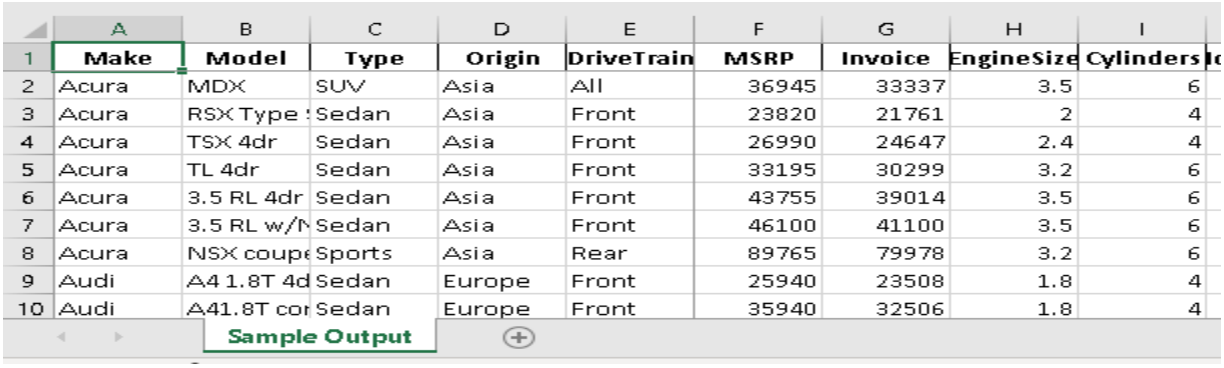
Openpyxl Python Package

The openpyxl Python library provides the ability to read and write Excel 2010 and later files. After the package has been installed, you can use documented methods to read, write, and update the various types of Excel files. Openpyxl provides more flexibility when creating and modifying XLSX output than the Pandas library, however both the Pandas package and openpyxl integrate well together. The Openpyxl can be used separately or together with the Pandas package when creating or modifying Excel files. There are various methods for specifying the worksheet names such as specifying the active worksheet, the worksheet position which starts at 0, and the name of the worksheet which is demonstrated with example 7. Commented out are some of the other methods of loading the worksheet.

1. Imports the load_work library to import existing XLSX files
2. Creates the workbook object **wb** with the worksheet information
3. Creates the worksheet object **ws** from the output XLSX file created in Example 6.
4. Add the Title method to the worksheet object ws to modify the tab name
5. Use the Save method with the workbook object **wb** to save the updated worksheet

Example 7.

```
from openpyxl import load_workbook
wb = load_workbook('c:/temp/cars.xlsx')
ws=wb["Demo"]
#ws=wb.active
#ws=wb.worksheets[0]
ws.title='Sample Output'
wb.save('c:/temp/openpyxl.xlsx')
```



	A	B	C	D	E	F	G	H	I
1	Make	Model	Type	Origin	DriveTrain	MSRP	Invoice	EngineSize	Cylinders
2	Acura	MDX	SUV	Asia	All	36945	33337	3.5	6
3	Acura	RSX Type S	Sedan	Asia	Front	23820	21761	2	4
4	Acura	TSX 4dr	Sedan	Asia	Front	26990	24647	2.4	4
5	Acura	TL 4dr	Sedan	Asia	Front	33195	30299	3.2	6
6	Acura	3.5 RL 4dr	Sedan	Asia	Front	43755	39014	3.5	6
7	Acura	3.5 RL w/N	Sedan	Asia	Front	46100	41100	3.5	6
8	Acura	NSX coupe	Sports	Asia	Rear	89765	79978	3.2	6
9	Audi	A4 1.8T 4d	Sedan	Europe	Front	25940	23508	1.8	4
10	Audi	A41.8T cor	Sedan	Europe	Front	35940	32506	1.8	4

Sample Output

Output 7. Output from Openpyxl package

SAS INTEGRATION TO PYTHON

There are several methods of integrating SAS with the Python open-source language. The PYTHON procedure is available with Viya 4 and allows Python to be called within a SAS program. The FCMP procedure using Python objects allows Python functions to be called within a SAS program within SAS 9.4M6 and later releases. There is also the SASPy library which is an open-source project created at SAS and provides the functionality of generating an analysis in SAS using Python-like syntax. There are other methods of integrating Python with SAS and Viya a subset of the methods is listed in Table 2.

SAS Integration	Language	Version
PROC PYTHON	Python	Viya 4
PROC FCMP	Python	SAS 9.4M6+
SASPy	Python	SAS 9.4+
Python Editor (SAS Studio)	Python	Viya 4
Python CAS API	Python	Viya 3.5 +

Table 2. Python Integration with SAS and Viya

THE PROC PYTHON PROCEDURE

The PYTHON procedure provides the ability to submit Python statements from an external Python script or enter Python statements directly within the SUBMIT and ENDSUBMIT statements. Some of the other highlights of the PROC PYTHON procedure include the ability to move data between SAS data sets and Pandas DataFrames, transfer SAS macro variables and Python variables, and call PROC FCMP functions within Python statements. The procedure has several callback functions that allow interaction between SAS and the compute server. The following example demonstrates the PROC Python syntax when the Python syntax is added between the SUBMIT and ENDSUBMIT statements, There is a required setup which can be found here.

```
proc python;
submit;
  <python-syntax>
endsubmit;
run;
```

THE PROC FCMP PROCEDURE

The PROC FCMP procedure and Python objects can be used to execute Python functions directly within SAS 9.4M6 and later releases. The Python function is added within the SUBMIT and ENDSUBMIT statements if run interactively and can consist of Python syntax as well as SAS callback functions which allows information to be passed back and forth between Python and SAS. The example below is a basic structure of the syntax needed to use the PROC FCMP procedure to use the openpyxl package to modify or create XLSX files.

1. The Declare statement adds an instance of the Python object with the name Py. The module name is not defined within the parenthesis and defaults to the PROC FCMP symbol name.
2. The submit block is used to specify the Python source statements.
3. The define statement is added to add a Python function
4. A comment is added “output:Mykey” specifying the value to return to SAS
5. The PUBLISH method makes the Python function available.
6. The CALL method invokes the function and sets the output to the return value created by the function.

```
proc fcmp;
declare object py(python); ❶
submit into py;  ❷
def MyFunc():   ❸
   "Output: MyKey" ❹
   <python statements>
endsubmit;
rc = py.publish();  ❺
rc = py.call("MyFunc");  ❻
run;
```

EXAMPLES USING OPEN SOURCE INTEGRATION

This section demonstrates creating or modifying XLSX, or PDF files using the Python open-source client using one or more of the Python libraries and one of the SAS integration methods such as PROC Python or PROC FCMP procedures. The examples modify or update files with features that are not currently available with the software and extended using open source. These features are:

- Password protecting an existing XLSX file created with ODS Excel
- Adding filters and sorts to the columns of the worksheet
- Adding images to a specific location on the worksheet and sizing
- Add data validation to an existing worksheet created using ODS Excel
- Adding data bars to specific columns of a worksheet
- Combining individual PDF files into a single PDF file

The examples in this section will use the same data source that is Heart.xlsx which is created using PROC EXPORT and the SASHELP.HEART table. Most of the examples in this section will modify .XLSX files using one of the open-source integration methods such as PROC FCMP using Python Objects, PROC PYTHON, or the SASPy library. The ODS Excel destination was excluded from the examples because of an existing defect listed here.

```
proc export data=sashelp.heart(keep=Sex Height Weight Diastolic Systolic
                               Cholesterol obs=100)
outfile="c:\temp\heart.xlsx"
dbms=xlsx replace;
run;
```

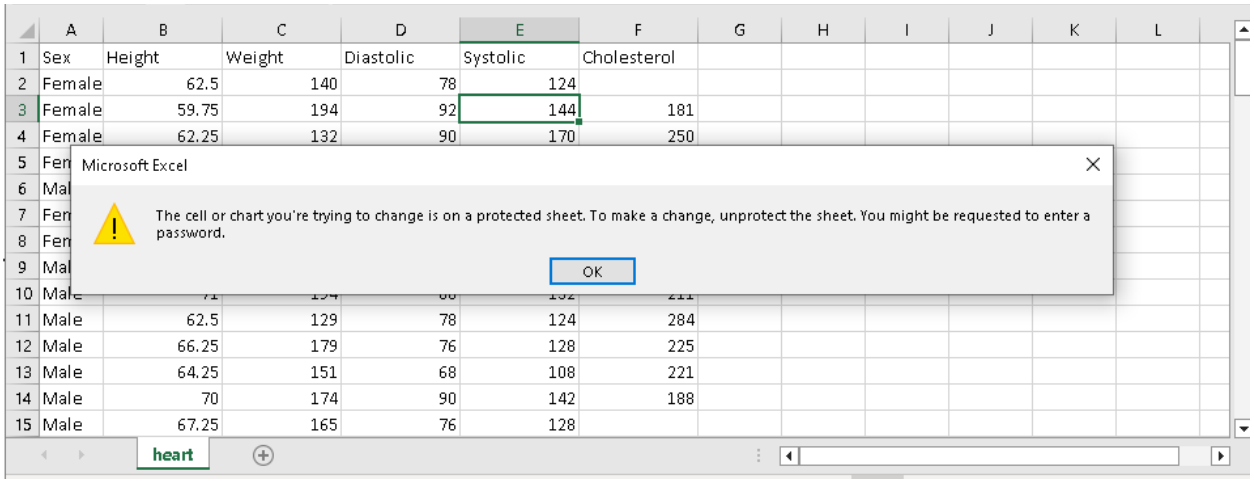
Password Protect Worksheets Created with ODS Excel

The ODS Excel destination has the capability of protecting worksheets using the PROTECT_ WORKSHEETS= ODS EXCEL option. This option can be toggled, however. to make the worksheet a little more secure you can add a password to the worksheet. Although more secure, this does not really provide any encryption. To add password protection to the worksheet, add the SET_PASSWORD method to the worksheet object which will request the password before any modification can be made on the worksheet. When sensitive patient data is in the worksheet, this is a way to make it more secure.

1. Use the PROC FCMP procedure to add a Python function AddPaass
2. Import load_workbook module and create workbook object **wb**
3. Create worksheet object **ws** with the active worksheet
4. The PROC FCMP is used to add the SET_PASSWORD method to the worksheet object.
5. The SAVE method is added to workbook object **wb** and creates a new workbook.

Example 8.

```
proc fcmp;
 declare object py(python);
 submit into py;
 def AddPass():
    "Output: MyKey"
    from openpyxl import load_workbook
    wb = load_workbook('c:/temp/passwords.xlsx')
    ws=wb.active
    ws.protection.set_password('test') ❼
    wb.save('c:/temp/password_update.xlsx') ❸
endsubmit;
rc = py.publish();
rc = py.call("AddPass");
run;
```



	A	B	C	D	E	F
1	Sex	Height	Weight	Diastolic	Systolic	Cholesterol
2	Female	62.5	140	78	124	
3	Female	59.75	194	92	144	181
4	Female	62.25	132	90	170	250
11	Male	62.5	129	78	124	284
12	Male	66.25	179	76	128	225
13	Male	64.25	151	68	108	221
14	Male	70	174	90	142	188
15	Male	67.25	165	76	128	

Output 8. Password protecting output

Adding Images to a Worksheet

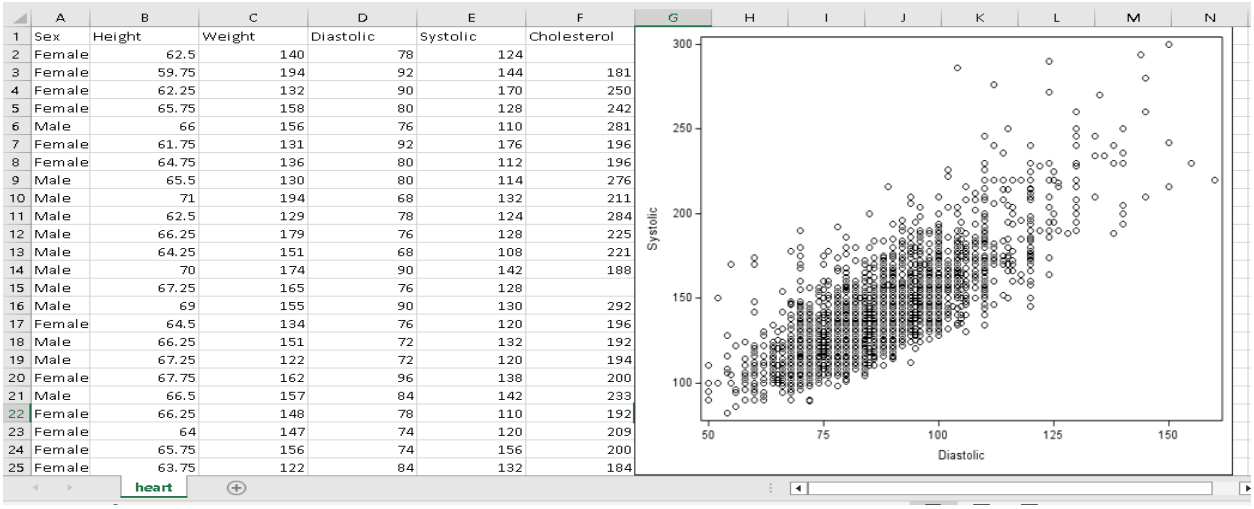
Using the ODS Excel destination doesn't support images in the same way as the other destinations. For example, none of the style attributes that support images such as PREIMAGE=, POSTIMAGE= or the BACKGROUND= are supported with the Excel destination. Images can be added using the PROC GSLIDE procedure or the Report Writing Interface using the IMAGE method as demonstrated in Example

3. These methods don't allow for specific image placement or sized. Using the openpyxl library, the images can be placed at specific locations and added to the worksheet using the ADD_IMAGE= method. There are times when a brand is required on the worksheet or simply a graphics image positioned.

Example 9

1. The graphics image created using PROC SGPLOT is generated using PROC SGPLOT along with the ODS Listing statement with the GPATH= option.
2. The PROC FCMP procedure is used to add the Python script within the SUBMIT and ENDSUBMIT statements.
3. The import package is added which makes the image library available.
4. The Python variable IMG is created to store the path and name of the image.
5. The ADD_IMAGE= method adds the image to the worksheet using the worksheet object **ws.**
6. The SAVE method is added to the workbook object **wb** which create a new worksheet.

```
  ods listing gpath="c:\temp"; ❶
  proc sgplot data=sashelp.heart;
  scatter x=diastolic y=systolic;
  run;

 proc fcmp; ❷
 declare object py(python);
 submit into py;
 def AddImg():
    "Output: MyKey"
    from openpyxl import load_workbook
    from openpyxl.drawing.image import Image ❸
    wb = load_workbook('c:/temp/heart.xlsx')
    ws=wb.active
    img = Image('c:/temp/SGplot1.png') ❹
    img.width = 500
    img.height =500
    ws.add_image(img,"G1") ❺
    wb.save('c:/temp/images_update.xlsx') ❻
endsubmit;
rc = py.publish();
rc = py.call("AddImg");
run;
```



	A	B	C	D	E	F
1	Sex	Height	Weight	Diastolic	Systolic	Cholesterol
2	Female	62.5	140	78	124	
3	Female	59.75	194	92	144	181
4	Female	62.25	132	90	170	250
5	Female	65.75	158	80	128	242
6	Male	66	156	76	110	281
7	Female	61.75	131	92	176	196
8	Female	64.75	136	80	112	196
9	Male	65.5	130	80	114	276
10	Male	71	194	68	132	211
11	Male	62.5	129	78	124	284
12	Male	66.25	179	76	128	225
13	Male	64.25	151	68	108	221
14	Male	70	174	90	142	188
15	Male	67.25	165	76	128	
16	Male	69	155	90	130	292
17	Female	64.5	134	76	120	196
18	Male	66.25	151	72	132	192
19	Male	67.25	122	72	120	194
20	Female	67.75	162	96	138	200
21	Male	66.5	157	84	142	233
22	Female	66.25	148	78	110	192
23	Female	64	147	74	120	209
24	Female	65.75	156	74	156	200
25	Female	63.75	122	84	132	184

Output 9. Adding Images to a Worksheet

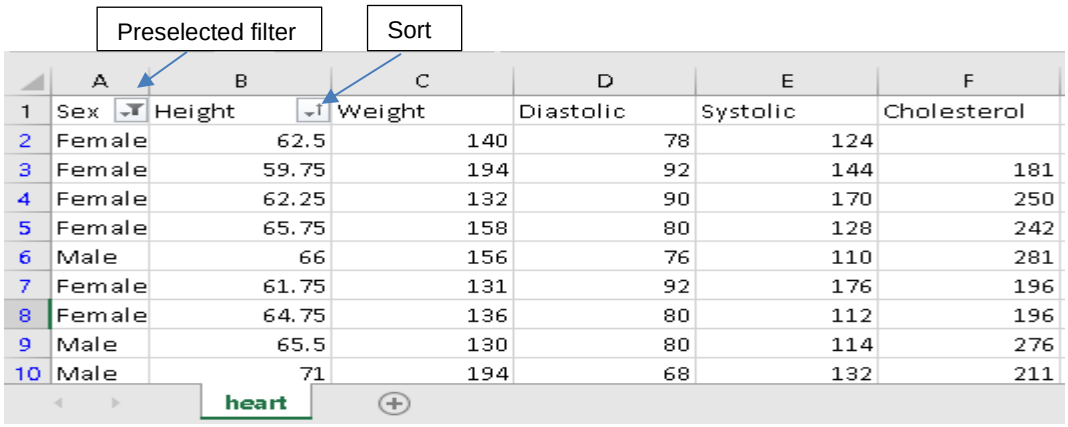
Adding Preselected Filters and Sorts

The ODS Excel destination provides the ability to add column filters to headers in sequence using the AUTOFILTER= ODS Excel option. This is a great way to gain insight into the data. An additional request may be to add preselected filters to a column or add filters out of sequence. This all can be done simply using the Openpyxl library. A sort can also be added to the column which is demonstrated with example 10. The worksheet has an AUTO_FILTER= attribute which exposes the REF= which is the range of the data. The ADD_FILTER_ COLUMN method is used to add the filter to the column. The sort order can also be specified using the ADD_SORT_CONDITION method with the range of data. Other custom or advanced filtering may be applied. This example adds parameters to the Python function..

Example 10

1. The REF= method adds the AUTO_FILTER attribute to the worksheet object and specifies the range.
2. The ADD_FILTER_COLUMN= method is added specifying the column and the preselect filter.
3. The ADD_SORT_CONDITION is used to sort a range of values

```
proc fcmp;
 declare object py(python);
 submit into py;
 def PyFilter(input,output):
     "Output: MyKey"
     from openpyxl import load_workbook
     wb = load_workbook(input)
     sheet=wb.active
     sheet.auto_filter.ref = 'A1:B100' ❶
     sheet.auto_filter.add_filter_column(0, ['Female']) ❷
     sheet.auto_filter.add_sort_condition('B1:B100') ❸
     wb.save(output)
endsubmit;
rc = py.publish();
rc = py.call("PyFilter","c:/temp/heart.xlsx","c:/temp/filter_update.xlsx");
run;
```



	A	B	C	D	E	F
1	Sex	Height	Weight	Diastolic	Systolic	Cholesterol
2	Female	62.5	140	78	124	
3	Female	59.75	194	92	144	181
4	Female	62.25	132	90	170	250
5	Female	65.75	158	80	128	242
6	Male	66	156	76	110	281
7	Female	61.75	131	92	176	196
8	Female	64.75	136	80	112	196
9	Male	65.5	130	80	114	276
10	Male	71	194	68	132	211

heart

Output 10. Adding preselected filters and Sorts:

Adding Data Bars to a Column

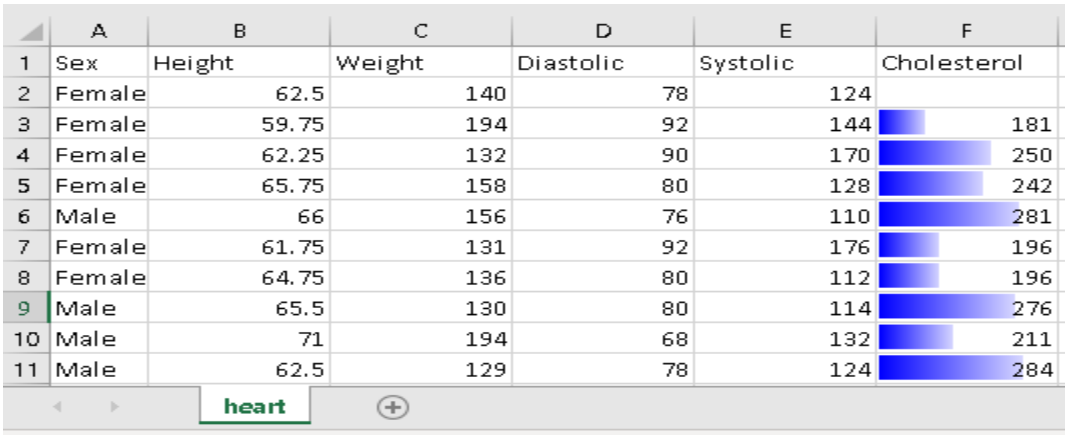
Conditional formatting can be added very easily using the PROC REPORT and the CALL DEFINE statement. his allows the highlighting of rows, columns, and individual table values. The openpyxl library in addition to highlighting values in each range can also add data bars which displays a graphical

representation of the value within the range. Parameters were added to the function specifying the input and output files.

Example 11

1. Add a data rule for the data bars that has a starting and ending value for the range along with a color for the bars.
2. The data rule for the range D2:D365 is added to the worksheet using the CONDITIONAL_FORMATTING_ADD worksheet method.

```
proc fcmp;
declare object py(python);
submit into py;
def DataBars(input,output):
    "Output: MyKey"
    from openpyxl import load_workbook
    from openpyxl.formatting.rule import DataBarRule
    wb = load_workbook(input)
    ws = wb.active
    data_bar_rule = DataBarRule(start_type="num",   ❶
                                start_value=150,
                                end_type="num",
                                end_value="300",
                                color="0000FF")
    ws.conditional_formatting.add("F2:F100",data_bar_rule) ❷
    wb.save(output)
endsubmit;
rc = py.publish();
rc = py.call("DataBars","c:/temp/heart.xlsx","c:/temp/databars_update.xlsx");
run;
```



	A	B	C	D	E	F
1	Sex	Height	Weight	Diastolic	Systolic	Cholesterol
2	Female	62.5	140	78	124	
3	Female	59.75	194	92	144	181
4	Female	62.25	132	90	170	250
5	Female	65.75	158	80	128	242
6	Male	66	156	76	110	281
7	Female	61.75	131	92	176	196
8	Female	64.75	136	80	112	196
9	Male	65.5	130	80	114	276
10	Male	71	194	68	132	211
11	Male	62.5	129	78	124	284

heart

Output 11. Conditional formatting using Databars

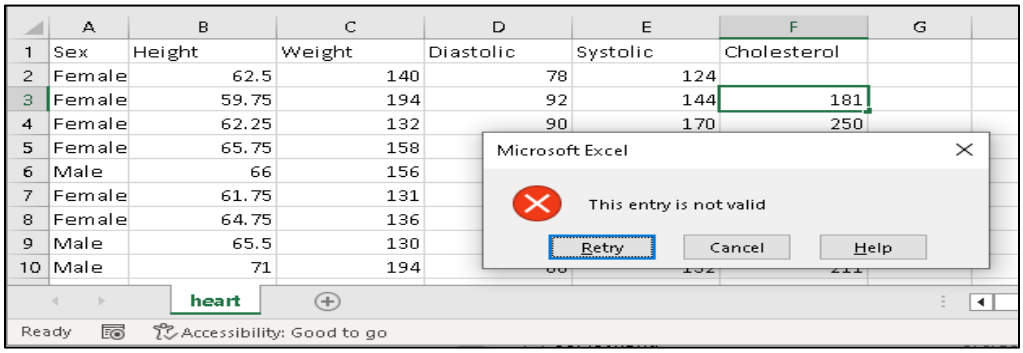
Adding Data Validation to the Worksheet

Neither ODS Excel nor PROC EXPORT can add data validation. Data validation allows you to validate values within a range of cells based on a rule. This could require that all values within the cell be valid integers or require a list of values to be specific values. This can also require that a value be within a range of values. The following example adds a rule using the Python variable DV that defines the valid values within a defined range of cholesterol numbers.

Example 12

1. The data validation rule is added with the Python variable DV.
2. An error is added using the ERROR method.
3. The data validation is added to the worksheet using the ADD_DATA_VALIDATION method.

```
proc fcmp;
declare object py(python);
submit into py;
def PyValidate(input,output):
      "Output: MyKey"
      from openpyxl import load_workbook
      from openpyxl.worksheet.datavalidation import DataValidation
      wb = load_workbook(input)
      ws = wb.active
      dv = DataValidation(type="whole", ❶
                          operator="greaterThan",
                          formula1=200)
      dv.error ='This entry is not valid' ❷
      ws.add_data_validation(dv) ❸
      dv.add('F3:F100')
      wb.save(output)
endsubmit;
rc = py.publish();
rc =
py.call("PyValidate","c:/temp/heart.xlsx","c:/temp/validate_update.xlsx");
run;
```



Output 12. Data validation added to the column Product

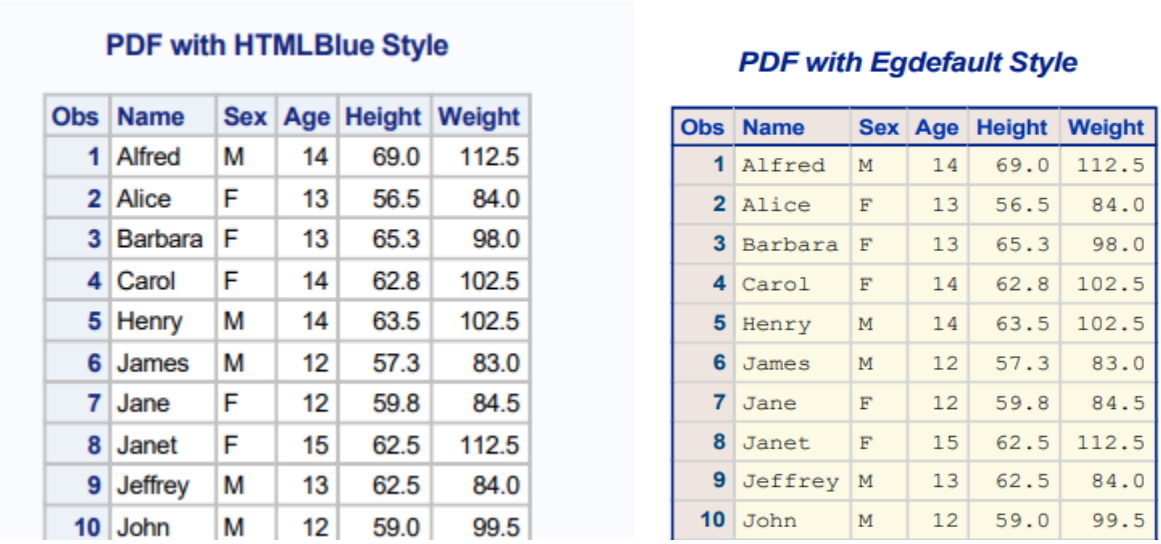
Combining PDF Files Created with SAS

The ODS PDF destination can generate PDF files, however, it does not have the ability to combine PDF files. Using the PyPDF2 package, one or more PDF files can be combined into a single file. In the example 13, two PDF files are generated using ODS PDF with separate styles. The two files are combined to generate a single PDF file. Each file retained its own styles.

Example 13

```
ods pdf file="c:\temp\file1.pdf" style=htmlblue;
  proc print data=sashelp.class; run;
ods pdf close;
ods pdf file="c:\temp\file2.pdf" style=egdefault;
  proc print data=sashelp.class; run;
ods pdf close;
```

```
proc fcmp;
declare object py(python);
submit into py;
def PyPDF():
   "Output: MyKey"
   from openpyxl import load_workbook
   from PyPDF2 import PdfFileMerger, PdfFileReader
   merger = PdfFileMerger()
   merger.append(PdfFileReader(open("c:/temp/file1.pdf", 'rb')))
   merger.append(PdfFileReader(open("c:/temp/file2.pdf", 'rb')))
   merger.write("c:/temp/merged.pdf")
endsubmit;
rc = py.publish();
rc = py.call("PyPDF");
run;
```



PDF with HTMLBlue Style

Obs	Name	Sex	Age	Height	Weight
1	Alfred	M	14	69.0	112.5
2	Alice	F	13	56.5	84.0
3	Barbara	F	13	65.3	98.0
4	Carol	F	14	62.8	102.5
5	Henry	M	14	63.5	102.5
6	James	M	12	57.3	83.0
7	Jane	F	12	59.8	84.5
8	Janet	F	15	62.5	112.5
9	Jeffrey	M	13	62.5	84.0
10	John	M	12	59.0	99.5

PDF with Egdefault Style

Obs	Name	Sex	Age	Height	Weight
1	Alfred	M	14	69.0	112.5
2	Alice	F	13	56.5	84.0
3	Barbara	F	13	65.3	98.0
4	Carol	F	14	62.8	102.5
5	Henry	M	14	63.5	102.5
6	James	M	12	57.3	83.0
7	Jane	F	12	59.8	84.5
8	Janet	F	15	62.5	112.5
9	Jeffrey	M	13	62.5	84.0
10	John	M	12	59.0	99.5

Output 13. The Merged PDF File

CONCLUSION

The Output Delivery System is a very powerful tool to generate output in most of the popular formats and with its broad range of ecosystem members is a great tool for reporting. When requested ODS can also generate dynamic output that can be further extended using open-source technology as demonstrated using the Python language. e basics of ODS, the ODS Destinations, styles and ODS and finally using ODS with other applications. ODS will make a difference in your report writing.

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