Altair SLC R procedure
user guide

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www.altair.com

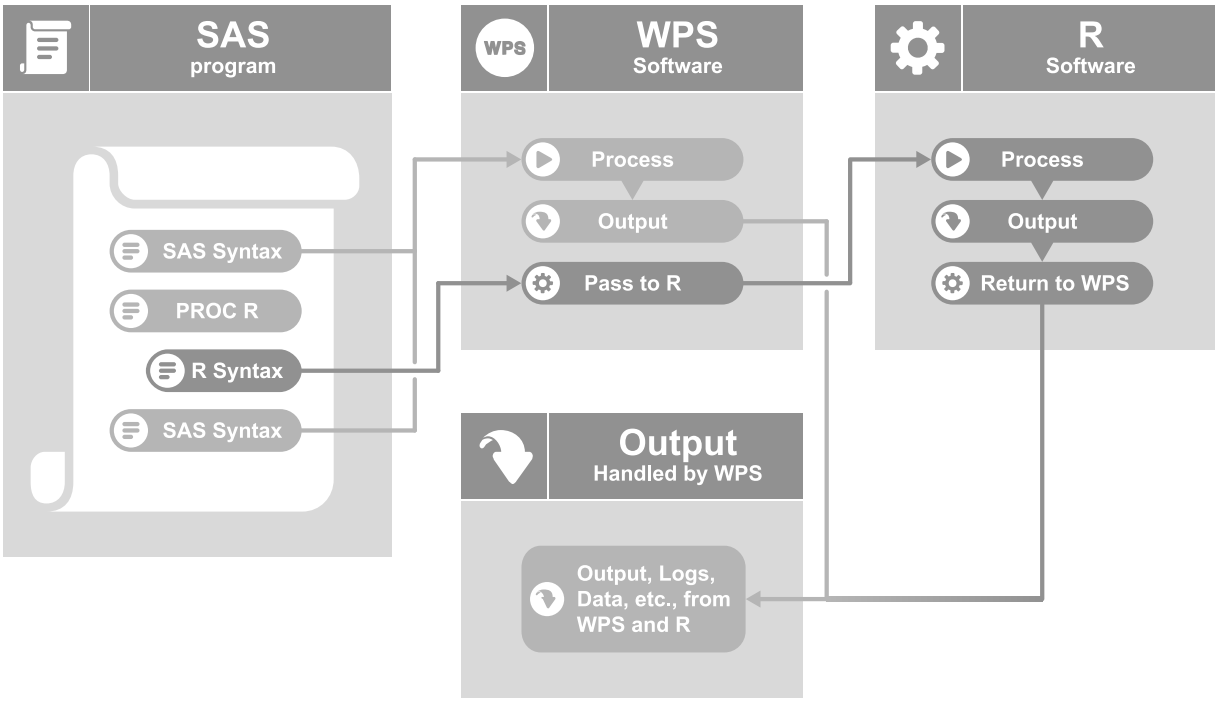
Contents

R Procedure

The R procedure enables SAS language programs to include code written in the R language.

Combining the R language and the SAS language enables the bulk of a data processing and analytics solution to be written in the industrial strength and high-performing SAS language, while also exploiting features present in the R language.

The following image shows how a SAS language program using the R procedure is processed.



Introduction

The R procedure enables SAS language programs to include code written in the R language.

By combining R and the SAS language you can:

- Use the SAS language to bulk process and prepare data, and pass the processed data to R.
- Use R packages you have previously developed for data analysis.
- Use R data analysis packages or solutions that may not be available in the SAS language.

We recommend that programs are mainly coded in the language of SAS, using R where specialist statistics are required.

Data is passed between the SAS language and R language environments using the `EXPORT` statement. Once data has been transferred, that data is made available as a `data.frame` object to an R program. On completion of the R program data can, if required, be returned to the SAS language environment using the `IMPORT` statement.

Setup and configuration

Setting the R environment for Altair SLC.

When using R with Altair SLC:

- You do not have to install extra modules, and there are no special licensing requirements to use the R procedure.

Altair SLC is not shipped with a copy of R. To use the R procedure, you need a separate installation of R.

Following R installation, set the *R_HOME* environment variable to point to the folder containing either `libr.dll` on Windows platforms or `libr.so` on UNIX or Linux platforms.

Installing the R interpreter

Windows platforms

The Windows installer package can be downloaded from *https://www.r-project.org/*.

By default, the R installation saves the installation location in the Windows registry which is where Altair SLC looks to identify the currently installed version.

UNIX or Linux platforms

Altair SLC requires the shared R library `libr.so` to interact with the R interpreter. This library is not included with the R binary distribution for UNIX platforms by default. On UNIX or Linux platforms, you need to either build R from source to include the required shared library, or install R using your systems package management system.

To build from source code:

1. You require a minimal set of pre-installed libraries before you can build R from source code. These are equivalent to the *build-essentials*package plus a JDK on Ubuntu.
2. Download the R source code from *https://www.r-project.org/* and follow the instructions included with the download. Ensure you use the --enable-R-shlib option when running configure to build the `libr.so` shared library, for example:

```
./configure --enable-R-shlib --prefix=$HOME/R
```

For more information, see the R documentation at *https://cran.r-project.org/*.

macOS platforms

The binary distribution of R can be installed directly from the R project website.

To use R with Altair SLC, the *R_HOME* variable must to be set to point to the installation directory containing the `libr.so` shared library. The default setting is: `/Library/Frameworks/Framework/Resources`. Because of the way applications are launched on macOS, it is not possible to set *R_HOME* in a shell profile script.

To use a specific version of R, you can modify the setting appropriately, for example: `/Library/Frameworks/Framework/Versions/3.0/Resources`

Setting the *R_HOME* environment variable

To locate the installed version of R, the *R_HOME* environment variable must be set.

On Windows platforms, the *R_HOME* environment variable must point to the folder containing the `libr.dll` file. On UNIX or Linux platforms, the *R_HOME* environment variable must point to the folder containing the `libr.so` file.

If you are running Altair SLC with R on a Unix or Linux platform, set the *R_HOME* variable to point to the folder containing `libr.so`.

If you have multiple installations of R, set R_HOME variable as part of the SAS language program you run in Altair SLC.

Set *R_HOME* before running Altair SLC

The *R_HOME* variable can be defined as a system variable, and used by all applications on your device that run R. It is not necessary to set the variable on the Windows platform if the default R installation location is used.

Set *R_HOME* in a SAS language program

The *R_HOME* variable can be set in a SAS language program using the `SET` system option, for example:

```
OPTIONS SET = R_HOME 'C:\Program Files\R\R-3.5.0';
```

This will set the *R_HOME* environment variable for duration of the execution of the SAS language program.

Using R with Altair SLC

Using R in a SAS language program enables you to use features that might not be available in Altair SLC.

Installed R packages can be imported and used within the in-line R code using the library statement, for example:

```
PROC R;
  SUBMIT;
    library(datasets)
    data(iris)
    summary(iris)
    plot(iris)
  ENDSUBMIT;
RUN;
```

Each subsequent use of the R procedure in a SAS language program can use the same R environment. This means any global variables or imported packages used in an R procedure invocation are available to all subsequent R procedure invocations.

Each R procedure invocation can include multiple blocks of in-line R language code, and use a combination of in-line R language code, and R programs run using the `EXECUTE` statement.

Data type conversion

Describes the correspondence between SAS language formats and R data types.

When you write data to a `data.frame` using the R procedure `EXPORT` statement, formatted data is converted to an equivalent R data type. Altair SLC has many formats that affect the output and display of data. Formats that only affect the layout of data output, such as adding currency symbols or comma separators, have no effect when writing data.

A `data.frame` is imported using the R procedure `IMPORT` statement. Any object that can be coerced into a `data.frame` using the `as.data.frame` R function is imported into the Altair SLC dataset.

Logical values

Logical values are converted into numeric values in the Altair SLC dataset. The values of vectors of type logical are converted as follows:

R Value	Altair SLC Value
TRUE	1
FALSE	0

Integer values

The R language value `NA`, which is represented as the minimum integer value (-2147483648) is converted to a SAS language missing value.

Real values

There are three special real numeric values in the R language:

- `NA` (Not Available). Represents an absent value.
- `NaN` (Not a Number). Represents an undefined value, or a value that cannot be displayed, for example the result of zero divided by zero.
- `Inf` (Infinity). Represent positive and negative infinite values. For example the result of trying to divide any value by zero.

These values are converted from the R language representation to the SAS language representation as follows:

R Value	Altair SLC Value
NA	. (missing value)
NaN	. (missing value)
+Inf	.I
-Inf	.M

Date values

Integer or real variables in the R language that have a `Date` class are formatted as `DATE9.` when imported into Altair SLC.

R language `Date` values represent a count of days from the Unix epoch of 1 January 1970 UTC. Imported variables are adjusted to take account of the SAS language epoch of 1 January 1960.

Datetime values

Real variables in the R language that have a `POSIXct` class are formatted as `DATETIME19.` when imported into Altair SLC.

R language `POSIXct` values represent a count of seconds from the Unix epoch of 1 January 1970 UTC. Imported variables are adjusted to take account of the SAS language epoch of 1 January 1960 and also use the value specified in the `GMTOFFSET` option of the `PROC R` statement.

Real variables in the R language that have a `times` class are formatted as `TIME8.` when imported into Altair SLC.

Character values

On import, Altair SLC scans a character variable and assigns a format that is the length of the longest string Individual values in a character variable that are `NA` (Not Available) are converted to the SAS language missing character value (`''`).

Factor values

An R language *factor* is a form of integer variable, where the values index a list of categorical variables (the list is known as a level in the R language). When imported into Altair SLC these are converted into character variables in the dataset. The variable is given a length equal to the longest string in the levels list.

Using R graphics

When launching an R session, Altair SLC configures R so that any graphics generated with the default graphics device are captured and included in ODS output.

The following program extends the previous example to include simple linear regression analysis and graphics.

1. Create a new program file, paste the following code, and save the file:

```
data source;
  do x=1 to 10;
    y=ranuni(-1);
    output;
  end;

PROC R;
  export data=source;
  submit;
    model <- lm(source$y ~ source$x)
    print(model)
    par(mfrow=c(2, 2))
    plot(model)
endsubmit;
run;
```

2. Run the program by clicking on the toolbar **Run** icon, and examine the HTML output.

   The output includes the printed R results together with a single graphic generated within the R session and routed into the Altair SLC output.

```
Call:
lm(formula = source$y ~ source$x)
Coefficients:
(Intercept)     source$x
     0.5344       0.0241
```

Using additional R packages

To use additional packages that are not included in your R installation, we recommend you install and check the basic operation of these packages in the interactive R environment. Installed packages can be used in an R program using the `library()` function.

An R environment launched by Altair SLC inherits the environment variables from the Altair SLC process. If third-party software is installed for use in R that requires, for example, additional entries in the *PATH* environment variable, Workbench must be restarted to register the changes.

SAS language macro processing

Using SAS language macros with in-line R programs.

When an in-line R program is run, the code between the `SUBMIT` and `ENDSUBMIT` statements is passed verbatim to the R interpreter. Macro processing is, therefore, suspended between the `SUBMIT` and `ENDSUBMIT` statements because:

- The R language uses the `&` and `%` characters as part of its syntax. Attempting to macro process the R source code might result in valid R syntax being misinterpreted as SAS language macro statements.
- The R language allows line-end style comments. The contents might contain, for example, unmatched apostrophes; tokenising of the R syntax using the regular SAS language parsing rules could not then occur.

Example

Demonstrates how to use a SAS language dataset in the R procedure to create a scatter plot diagram.

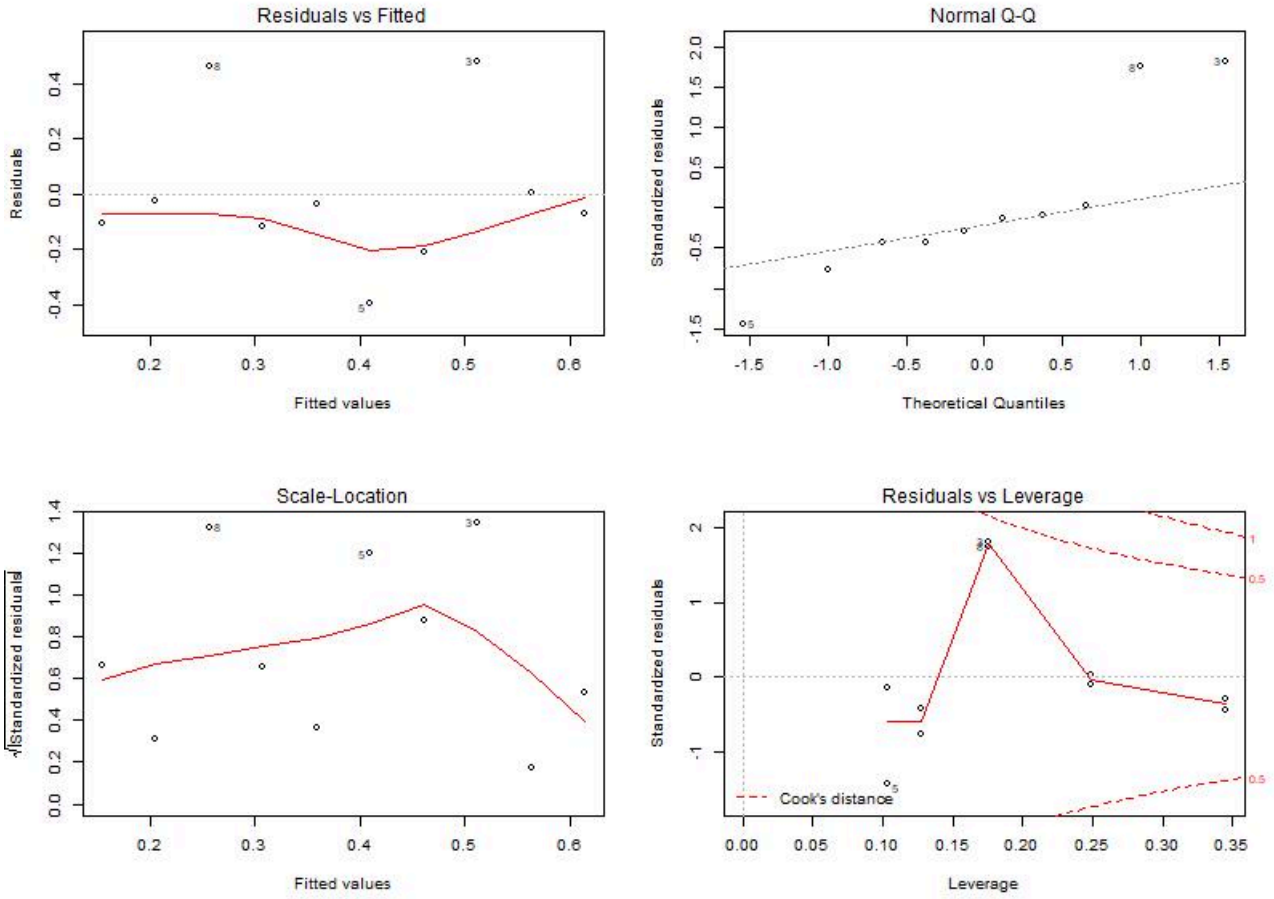
The following example creates a dataset in a SAS language DATA step, and then uses the `EXPORT` statement to pass that dataset to the R environment. The dataset is converted to a `data.frame` as part of the export, and the data.frame is used to create plots in a grid two plots wide and two plots deep.

An output PDF file destination is created using the SAS language Output Delivery System (ODS). Adding PDF to the output destinations includes the printed data.fram content and returned plot image file in the PDF output. The PDF is saved and the output can be viewed in a PDF viewer.

```
ODS PDF FILE='scatter_plot.pdf';
DATA SOURCE;
  DO X=1 TO 10;
    Y=RANUNI(-1);
    OUTPUT;
  END;
RUN;

PROC R;
  EXPORT DATA=source;
  SUBMIT;
    str(source)
    print(source)
    model <- lm(source$Y ~ source$X)
    print(model)
    par(mfrow=c(2, 2))
    plot(model)
    x <- (1:10)
  ENDSUBMIT;
  IMPORT R=x;
RUN;
ODS PDF CLOSE;
```

This creates the following plot in the ODS PDF output:

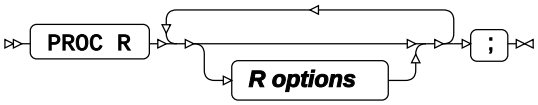


R procedure reference

Describes the syntax and options for `PROC R` and its contained statements.

PROC R

Invokes the R environment that enables the execution of in-line or external R language programs.



Datasets created in Altair SLC can be made available to the R program using the `EXPORT` statement, and a dataset imported from the R program into Altair SLC using the `IMPORT` statement.

An R program can be either written in-line in the R procedure, or run from a separate file:

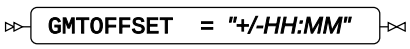
- To run an in-line R program, use the `SUBMIT` and `ENDSUBMIT` statements.
- To run an R program stored in an external file use the `EXECUTE` statement.

The R environment is exited using a `RUN` statement.

Options

The following options are available.

GMTOFFSET
Specifies the offset to UTC applied when moving datasets between the SAS language and R language environments to take account the current time zone.



Date and time values in the R language are represented in UTC (Coordinated Universal Time) with an associated time zone. In the SAS language date and time values have no implied time zone. The specified GMTOFFSET is applied when using the ASSIGN, EXPORT, or IMPORT statements.

KEEP

Specifies that the current R environment is not terminated when the procedure exits.

When specified, the current R environment is kept active when the current procedure exits, and the environment is used in the next invocation of the R procedure in the same program. If that invocation does not specify KEEP, the environment is terminated when the procedure exits.

The default behaviour is to terminate the R environment at the end of the procedure. Specifying KEEP keeps the current R environment, including any modules loaded during the execution of a R program, to be used in the next invocation of PROC R.

You can specify the RKEEP system option to use the same R environment for the duration of the execution of the SAS language program.

LIB

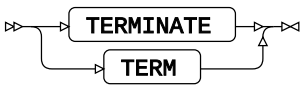
Specifies the default library location for the procedure step. The default location is the WORK library.

The LIB location is used:

- When exporting a dataset, and *libname* is not specified as part of the path for the DATA option of the EXPORT statement.
- When importing a dataset, and *libname* is not specified as part of the path for the DATA option of the IMPORT statement.
- When saving an R object to a SAS language catalog, and *libname* is not specified as part of the path for the CATALOG option of the SAVE statement.
- When loading an R object to a SAS language catalog, and *libname* is not specified as part of the path for the CATALOG option of the LOAD statement.

TERMINATE

Specifies that the R environment is terminated when the procedure exits.



Specifying TERMINATE stops the current R environment even if the RKEEP system option has been specified.

TIMESASCHRON

Specifies whether time values are represented in R using the `chron` class.

By default, time values are stored in the R `POSIXct` type, representing a count of seconds from midnight. When `TIMESASCHRON` is specified, time values are stored in R as `chron.times` types.

To use the `TIMESASCHRON` option, you must include the `chron` package in your R environment using the R `library()` statement.

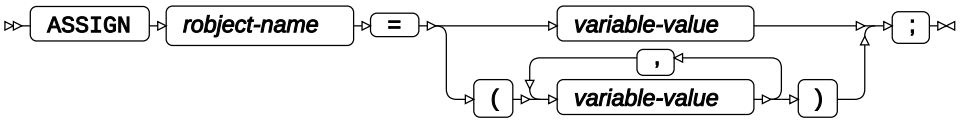
Example

The following example shows how to use `PROC R` to find the version of the R interpreter used with Altair SLC. Version information is written to ODS output.

```
PROC R;
  SUBMIT;
    print(R.version)
  ENDSUBMIT;
RUN;
```

ASSIGN

The `ASSIGN` statement can be used to assign SAS language variable values to an R vector.



The `ASSIGN` statement is used to pass parameters to an R program, and the specified *robject-name* can be used in an in-line program or a program run using the `EXECUTE` command. *robject-name* is case sensitive and, unlike SAS language variables, must be referred to in the R program using the same case as in the `ASSIGN` definition.

Variables can be generated using SAS language macro variable expansion or execution. This enables you to preprocess variables using the SAS language and pass the result to an R program.

robject-name

Specifies one or more variable values to pass to an R program. The *robject-name* specifies the variable name by which the *variable-value* is referenced in the R program.

The *robject-name* can be defined using a SAS language name literal (`'robject.name'N`) to create an R object that would not be valid in the SAS language. For example, to assign a value `Peter` to an R object `employee.firstname`, the `ASSIGN` statement would be:

```
ASSIGN 'employee.firstname'N = 'Peter';
```

Multiple *variable-value*s can be assigned to a single R language object. In this case, all values must be of the same type and in a comma-separated list in parenthesis.

Passing multiple variables to R

In this example, multiple vector variables are passed from a SAS language program to an R program that converts the vectors into a data frame.

```
PROC R;
  ASSIGN Nu = (1, 2, 3, 4, 5);
  ASSIGN Ch = ('Cyan', 'Magenta', 'Yellow', 'Black', 'Green');
  SUBMIT;
    DFrame <- data.frame(Nu, Ch)
    print (DFrame)
  ENDSUBMIT;
RUN;
```

This produces the following output:

```
  Nu      Ch
   1    Cyan
   2 Magenta
   3  Yellow
   4   Black
   5   Green
```

Assigning a SAS language macro variable to an R object

In this example, the SAS language macro variable *PARM* is passed to an R program to determine the sample size in a randomly-generated sample.

```
%LET PARM=15;
PROC R;
  ASSIGN parm=&PARM;
  SUBMIT;
    x<-sample(1:3, parm, replace=TRUE)
    print(x);
  ENDSUBMIT;
RUN;
```

This produces the following output:

```
[1] 1 1 3 3 3 2 1 1 3 1 1 3 3 1 1
```

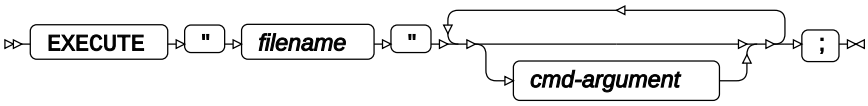
ENDSUBMIT

Specifies the end of an in-line R language program.

The `ENDSUBMIT` statement must be entered at the start of a new line after the R language program.

EXECUTE

Runs an R program stored in a separate file.



The `EXECUTE` statement is an alternative to using the `SUBMIT` statement. It allows the R code to be placed in a separate file and enables you to run the same program in both Altair SLC and an interactive R environment.

filename

A quoted string containing the path of the R program file. *filename* can be either an absolute path or a relative path.

When using Workbench to run an R language program, if a relative path is specified the root of the path is the Workspace. For example, to run a file named `math.r` from a project named `calculate`, the relative path is `calculate/math.r`.

cmd-argument

Specifies a command line argument passed to the R program.

An example of executing an R program stored in a file

In this example, an R program stored in an external file `model.r` is executed in the R procedure. The contents of `model.r` source file:

```
    model <- lm(source$Y ~ source$X)
    print(model)
    par(mfrow=c(2, 2))
    plot(model)
```

The following program creates a dataset. The dataset is passed to the R program using the `EXPORT` statement before the program is run using the `model.r` file:

```
DATA SOURCE;
  DO X=1 TO 10;
    Y=RANUNI(-1);
    OUTPUT;
  END;

PROC R;
  EXPORT DATA=source;
  EXECUTE "model.r";
RUN;
```

EXPORT

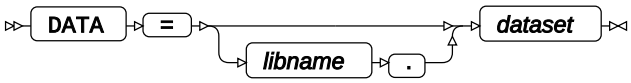
Enables a SAS language dataset to be converted to an R `data.frame` and referenced in an R program.

Export options

The following options are available with the `EXPORT` statement.

DATA

Specifies the name of the dataset.

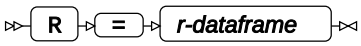


The library location can be specified using either *libname* in the `DATA` option, or the `LIB` option of the `PROC R` statement:

- If *libname* is specified, that location is always used.
- If the `LIB` option of the `PROC R` statement is specified and *libname* is not specified, the location in the `LIB` option is used.
- If neither *libname* or the `LIB` option on the `PROC R` statement are specified, the `WORK` location is used.

R

Specifies the name of the `data.frame` as used in the R environment.



If this option is not specified, the *r-dataframe* default is the *dataset* name specified in the `DATA` option. If you use the default *dataset* name in an in-line R language program, the variable name must match the case used in the `DATA` option.

An example of exporting data from Altair SLC to R

The following example creates a dataset containing two numeric columns. The dataset is exported to the R environment and the content of the `data.frame` printed to ODS output.

```
DATA SOURCE;
  DO X=1 TO 10;
    Y=RANUNI(-1);
    OUTPUT;
  END;

PROC R;
  EXPORT DATA=SOURCE;
  SUBMIT;
    str(source)
  ENDSUBMIT;
RUN;
```

This produces the following output:

```
'data.frame': 10 obs. of  2 variables:
 $ x: num  1 2 3 4 5 6 7 8 9 10
 $ y: num  0.371 0.924 0.59 0.434 0.962 ...
```

IMPORT

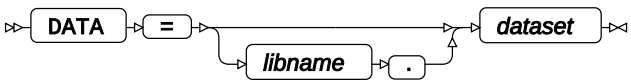
Enables an R language `data.frame` to be converted to a SAS language dataset and referenced in a SAS language program.

Import options

The following options are available with the `IMPORT` statement.

DATA

Specifies the two level SAS-language dataset name.



The library location can be specified using either *libname* in the `DATA` option, or the `LIB` option of the `PROC R` statement:

- If *libname* is specified, that location is always used.
- If the `LIB` option of the `PROC R` statement is specified and *libname* is not specified, the location in the `LIB` option is used.

- If neither *libname* nor the `LIB` option on the `PROC R` statement are specified, the `WORK` location is used.

If this option is not specified, the *dataset* default is the *r-dataframe* name specified in the `R` option.

R

Specifies the name of the `data.frame` as used in the R environment. Must be specified

r-dataframe is case sensitive and must match the case used for the imported `data.frame` in the R program.

LOAD

The `LOAD` statement deserialises an *R object* stored in a SAS language catalog.

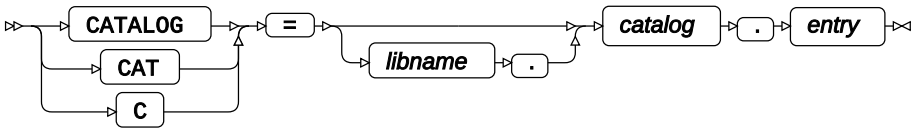
The `SAVE` and `LOAD` and statements enable an R object to be serialised and stored in a SAS language catalog and later deserialised in an Altair SLC session. The `SAVE` statement serialises an R object and stores it in an entry in a catalog. The `LOAD` statement deserialises an R object from a catalog.

Load options

The following options are available with the `LOAD` statement.

CATALOG

Specifies the catalog from which the stored R object is loaded.



A SAS language catalog is defined using:

libname

Specifies the name of the library in which the catalog is stored. The library location can be specified using either *libname* or the `LIB` option of the `PROC R` statement.

- If *libname* is specified, that location is always used.
- If the `LIB` option of the `PROC R` statement is specified and *libname* is not specified, the location in the `LIB` option is used.
- If neither *libname* nor the `LIB` option on the `PROC R` statement are specified, the `WORK` location is used.

catalog
Specifies the name of the catalog.

entry
Specifies the name of the R object in the catalog.

R
Specifies the variable name for the loaded R object as used in the R language program.

Because R is case-sensitive, *robject-name* must match the case used of the R variable name. The name can be specified using name literal syntax (for example `"r.object.name"N`) if the name of the R object does not follow the normal rules for identifiers in the SAS language.

An example of using the LOAD statement

```
proc r;
  load cat=catalog.entry r='target.object'n;
run;
```

SAVE

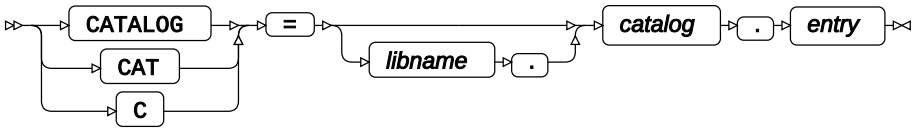
Enables R objects to be serialised and stored in a SAS language catalog.

The SAVE and LOAD and statements enable an R object to be serialised and stored a SAS language catalog and later deserialised in Altair SLC. The SAVE statement serialises an R object and stores it in an entry in a catalog. The LOAD statement deserialises an R object from a catalog.

Save options

The following options are available with the SAVE statement.

CATALOG
Species the location in which the R object will be saved.



The library location can be specified using either *libname* or the LIB option of the PROC R statement:

libname

Specifies the name of the library in which the catalog is stored. The library location can be specified using either *libname* or the `LIB` option of the `PROC R` statement.

- If *libname* is specified, that location is always used.
- If the `LIB` option of the `PROC R` statement is specified and *libname* is not specified, the location in the `LIB` option is used.
- If neither *libname* nor the `LIB` option on the `PROC R` statement are specified, the `WORK` location is used.

catalog

Specifies the name of the catalog.

entry

Specifies the name of the R object in the catalog.

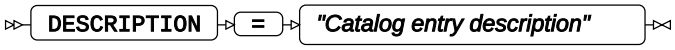
R

Specifies the name of the R object to save to the catalog. Must be specified.

Because R is case-sensitive, the case of *robject-name* must match the object name in the R program. The name can be specified using name literal syntax (for example `"r.object.name"N`) if the name of the R object does not follow the normal rules for identifiers in the SAS language.

DESCRIPTION

Specifies a description string saved with the catalog entry.



The description is displayed in the output from the `PROC CATALOG` statement.

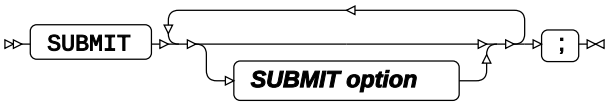
The catalog entry will have a type of `ROBJECT`.

An example of saving an R object to an Altair SLC catalog

```
proc r;
  save cat=catalog.entry r='source.object'n;
run;
```

SUBMIT

Specifies the start of an in-line R language program.



An in-line R language program is defined as part of the `R` procedure in a SAS language program. The `SUBMIT` statement marks the start of the program, and the `ENDSUBMIT` statement marks the end.

An R language program must start on a new line after the `SUBMIT` statement, and the `ENDSUBMIT` statement must appear at the beginning of a line on its own.

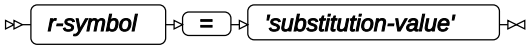
Multiple in-line R language programs can exist in a single R procedure environment. Each R language program is executed as it is encountered. Variables defined in one R language program can be used in subsequent in-line programs in the same R procedure environment.

SUBMIT options

The following option can be used with the `SUBMIT` statement.

r-symbol

Enables the replacement of a symbol in the R program with a string.



Before being passed to the R environment, an in-line R program is pre-processed to replace any *r-symbol* defined in the program with the content of the *substitution-value*. If the *substitution-value* is a string, it must be surrounded by quotation marks. If *substitution-value* is a SAS language macro variable, it must be prepended by an ampersand (&), but quotation marks are not required.

The *r-symbol* name is case sensitive and must be referred to in the R program using the same case as in the `SUBMIT` statement definition.

```
PROC R;
SUBMIT greeting = 'Hello World';
r.welcome <- "&greeting."
print (r.welcome)
ENDSUBMIT;
RUN;
```

The syntax for replacing a defined *r-symbol* is the same as that used for SAS language macro variable substitution, the name of the defined *r-symbol* is prepended by an ampersand (&) in the inline code.

SUBMIT statement – basic example

The following example shows how to incorporate an R-language program into a SAS language program:

```
PROC R;
SUBMIT;
x <- (1:10)
print(x)
ENDSUBMIT;
RUN;
```

Which outputs the following:

```
 [1]  1  2  3  4  5  6  7  8  9 10
```

SUBMIT statement – using a macro variable in an R program

The following example shows how to pass a variable from a SAS language program to an R language program. The variable *welcome* is defined using the SAS language `%LET` macro. The specified macro variable is assigned to the *r-symbol* of the `SUBMIT` statement. The *r-symbol* is then referenced in the inline R language program:

```
%LET welcome = 'Hello World';
PROC R;
SUBMIT greeting = &welcome;
r.welcome <- "&greeting"
print (toupper(r.welcome))
ENDSUBMIT;
RUN;
```

Which outputs the following:

```
[1] "HELLO WORLD"
```

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