Minitab® 17

Getting Started with Minitab 17

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1 Introduction

Objectives

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Overview

Getting Started with Minitab 17 introduces you to some of the most commonly used features and tasks in Minitab.

Most statistical analyses require that you follow a series of steps, often directed by background knowledge or by the subject area that you are investigating. Chapters 2 through 5 illustrate the following steps:

- Explore data with graphs
- Conduct statistical analyses
- Assess quality
- Design an experiment

In chapters 6 through 10, you learn to do the following:

- Use shortcuts to automate future analyses
- Generate a report
- Prepare worksheets
- Customize Minitab

The story

A company that sells books online has three regional shipping centers. Each shipping center uses a different computer system to enter and process orders. The company wants to identify the most efficient computer system and to use that computer system at each shipping center.

Throughout *Getting Started with Minitab 17*, you analyze data from the shipping centers as you learn to use Minitab. You create graphs and perform statistical analyses to identify the shipping center that has the most efficient computer system. You then concentrate on the data from this shipping center. First, you create control charts to test whether the shipping center's process is in control. Then, you perform a capability analysis to test whether the process is operating within specification limits. Finally, you perform a designed experiment to determine ways to improve those processes.

You also learn about session commands, and how to generate a report, prepare a worksheet, and customize Minitab.

The Minitab user interface

Before you start your analysis, open Minitab and examine the Minitab user interface. From the Windows taskbar, choose **Start** > **All Programs** > **Minitab** > **Minitab 17 Statistical Software**.

By default, Minitab opens with two windows visible and one window minimized.

Session window
> The Session window displays the results of your analyses in text format. Also, in this window, you can enter session commands instead of using Minitab's menus.

Worksheet
> The worksheet, which is similar to a spreadsheet, is where you enter and arrange your data. You can open multiple worksheets.

Project Manager
> The third window, the Project Manager, is minimized below the worksheet.
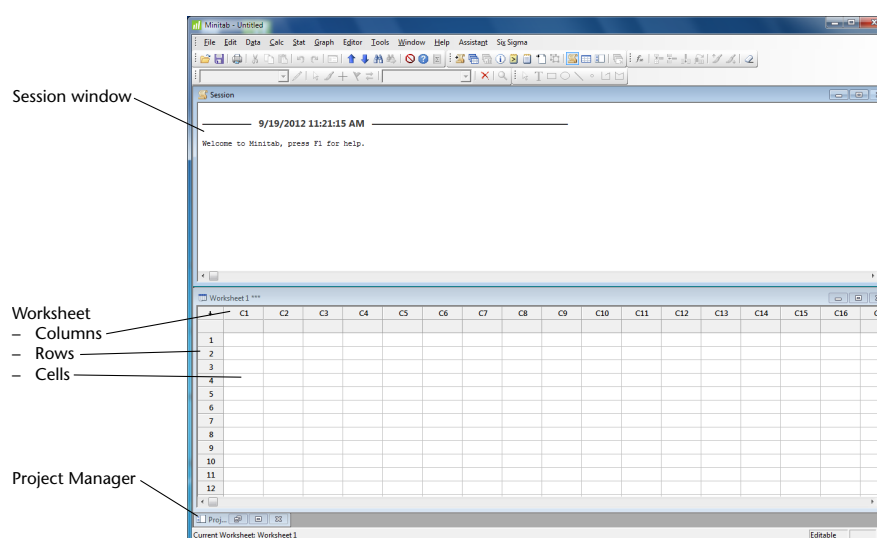
Projects and worksheets

In a project, you can manipulate data, perform analyses, and generate graphs. Projects contain one or more worksheets.

Project (.MPJ) files store the following items:
- Worksheets
- Graphs
- Session window output
- Session command history
- Dialog box settings
- Window layout
- Options

Worksheet (.MTW) files store the following items:
- Columns of data

- Constants
- Matrices
- Design objects
- Column descriptions
- Worksheet descriptions

Save your work as a project file to keep all of your data, graphs, dialog box settings, and options together. Save your work as a worksheet file to save only the data. A worksheet file can be used in multiple projects. Worksheets can have up to 4,000 columns. The number of worksheets that a project can have is limited only by your computer's memory.

Data types

A worksheet can contain the following types of data.

Numeric data
Numbers, such as 264 or 5.28125.

Text data
Letters, numbers, spaces, and special characters, such as Test #4 or North America.

Date/time data
Dates, such as Mar-17-2013, 17-Mar-2013, 3/17/13, or 17/03/13.

Times, such as 08:25:22 AM.

Date/time, such as 3/17/13 08:25:22 AM or 17/03/13 08:25:22.

Elapsed time, such as [12]:22:14.

Open and examine a worksheet

You can open a new, empty worksheet at any time. You can also open one or more files that contain data, such as a Microsoft Excel file. When you open a file, you copy the contents of the file into the current Minitab project. Any changes that you make to the worksheet while you are in the project do not affect the original file.

The data for the three shipping centers are stored in the worksheet ShippingData.MTW.

1.   Choose **Help** > **Sample Data**.

2. Double-click the Getting Started folder, then double-click ShippingData.MTW.
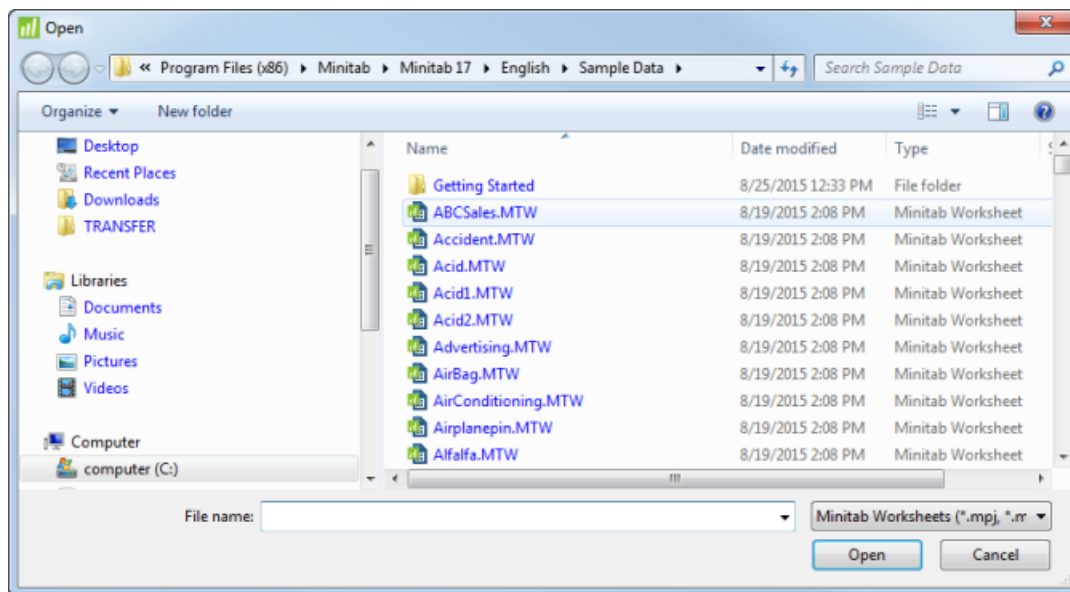
The data are arranged in columns, which are also called variables. The column number and name are at the top of each column.

In the worksheet, each row represents a single book order. The columns contain the following information:

- Center: shipping center name

- Order: order date and time

- Arrival: delivery date and time

- Days: delivery time in days

- Status: delivery status

  On time indicates that the book shipment was received on time. Back order indicates that the book cannot be shipped yet because it is not currently in stock. Late indicates that the book shipment was received six or more days after the order was placed.

- Distance: distance from the shipping center to the delivery location

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In the next chapter

Now that you have a worksheet open, you are ready to start using Minitab. In the next chapter, you use graphs to check the data for normality and examine the relationships between variables.

2 Graphing Data

Objectives

- Create, interpret, and edit histograms on page 10
- Create and interpret scatterplots with the Minitab Assistant on page 15
- Arrange multiple graphs on one page on page 18
- Save a project on page 20

Overview

Before you perform a statistical analysis, you can use graphs to explore data and assess relationships between the variables. Also, you can use graphs to summarize data and to help interpret statistical results.

You can access Minitab's graphs from the **Graph** and **Stat** menus. Built-in graphs, which help you interpret results and assess the validity of statistical assumptions, are also available with many statistical commands.

Minitab graphs include the following features:
- Pictorial galleries to help you choose a graph type
- Flexibility in customizing graphs
- Graph elements that you can change
- Option to be automatically updated

This chapter explores the shipping data worksheet that you opened in the previous chapter. You use graphs to check normality, compare means, explore variability, and examine the relationships between variables.

Tip   For more information about Minitab graphs, go to **Graphs** in the Minitab Help index. To access the Minitab Help index, open Minitab, choose **Help** > **Help**, then click the **Index** tab in the left pane.

Explore the data

Before you perform a statistical analysis, first create graphs that display important characteristics of the data. For the shipping data, you want to know the mean delivery time for each shipping center and how the data vary within each shipping center. You also want to determine whether the shipping data follow a normal distribution, so that you can use standard statistical methods for testing the equality of means.

Create a paneled histogram

To determine whether the shipping data follow a normal distribution, create a paneled histogram of the time lapse between order date and delivery date.

1. If you are continuing from the previous chapter, go to step 4. If not, start Minitab.
2. Choose **Help** > **Sample Data**.
3. Double-click the Getting Started folder, then double-click ShippingData.MTW.

4.   Choose **Graph** > **Histogram**.
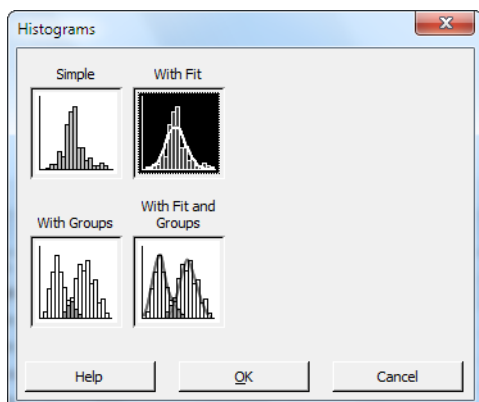
5.   Click **With Fit**, then click **OK**.
6.   In **Graph variables**, enter *Days*.
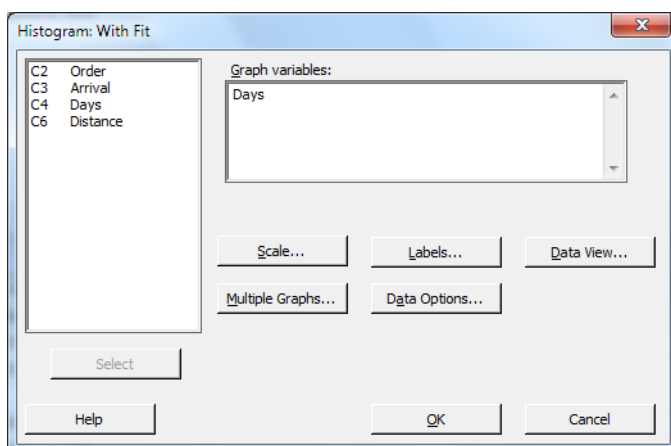
7.   Click **Multiple Graphs**.
8.   On the **By Variables** tab, in **By variables with groups in separate panels**, enter *Center*.
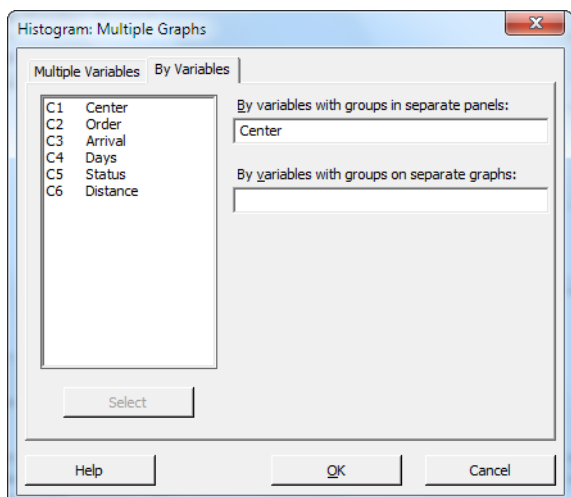
9.   Click **OK** in each dialog box.

Note

To select variables in most Minitab dialog boxes, use one of the following methods:

- Double-click the variables in the variables list box.

- Highlight the variables in the list box, and then click **Select**.

- Type the variables' names or column numbers.

Histogram with groups in separate panels
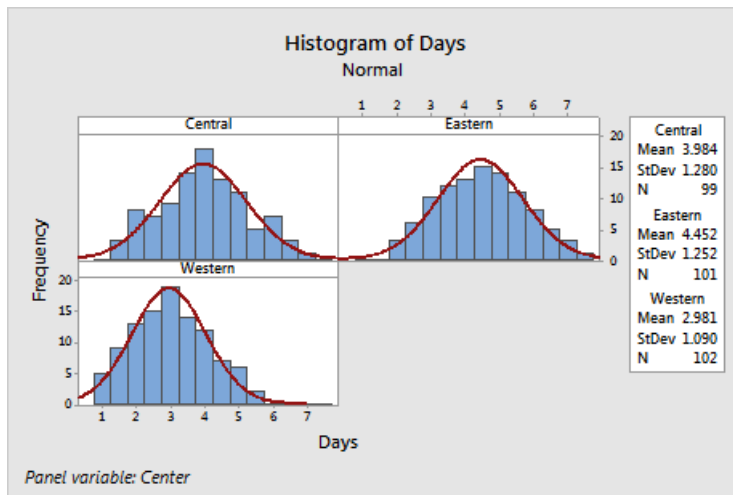
Interpret the results

The histograms seem to be approximately bell-shaped and symmetric about the means, which indicates that the delivery times for each center are approximately normally distributed.

Rearrange the paneled histogram

For the graph that you created, you want to rearrange the three panels so that comparing the means and variation is easier.

1.   Right-click the histogram, then choose **Panel**.

2. On the **Arrangement** tab, in **Rows and Columns**, select **Custom**. In **Rows**, enter *3*. In **Columns**, enter *1*.
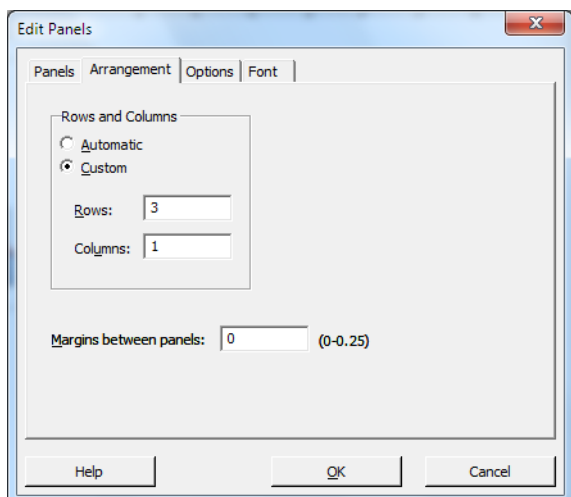
3. Click **OK**.

Histogram with panels arranged in one column
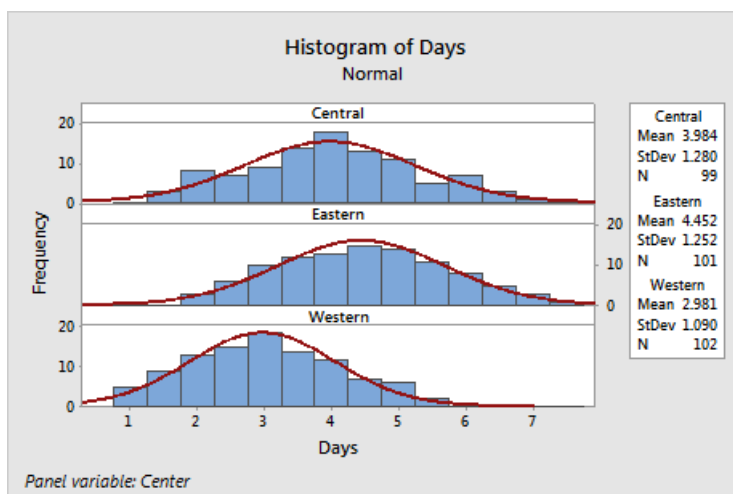
Interpret the results

The mean delivery times for each shipping center are different:

- Central: 3.984 days
- Eastern: 4.452 days
- Western: 2.981 days

The histogram shows that the Central and Eastern centers are similar in both mean delivery time and spread of delivery time. In contrast, the mean delivery time for the Western center is shorter and the distribution is less spread out. Analyzing Data on page 22 shows how to detect statistically significant differences between means using ANOVA (analysis of variance).

Tip   If your data change, Minitab can automatically update graphs. For more information, go to **Updating graphs** in the Minitab Help index. To access the Minitab Help index, open Minitab, choose **Help** > **Help**, then click the **Index** tab in the left pane.

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Edit the title and add a footnote

To help your supervisor quickly interpret the histogram, you want to change the title and add a footnote.

1. Double-click the title, **Histogram of Days**.
2. In **Text**, enter *Histogram of Delivery Time*.
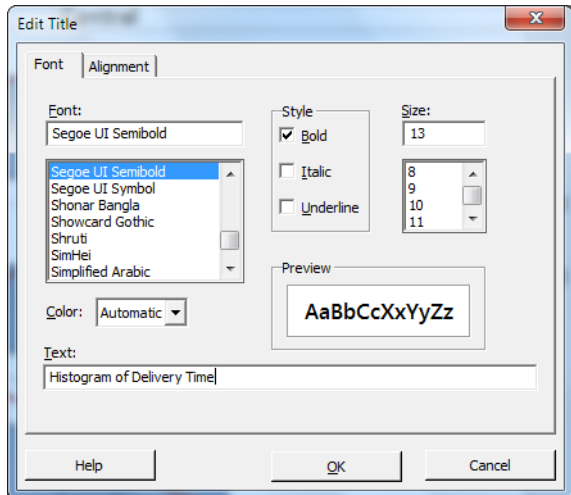
3. Click **OK**.
4. Right-click the histogram, then choose **Add** > **Footnote**.
5. In **Footnote**, enter *Western center: fastest delivery time, lowest variability*.
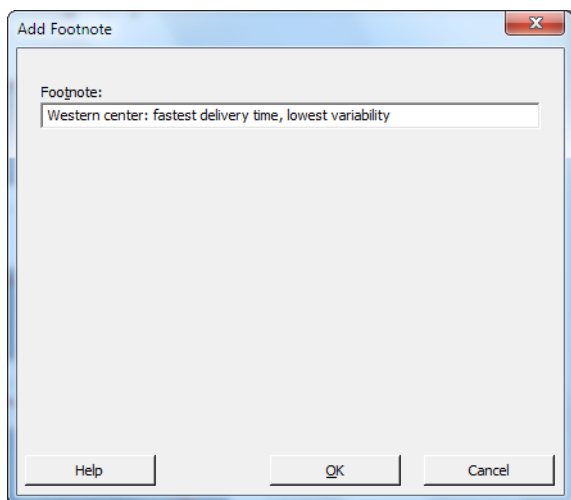
6. Click **OK**.

Histogram with edited title and new footnote
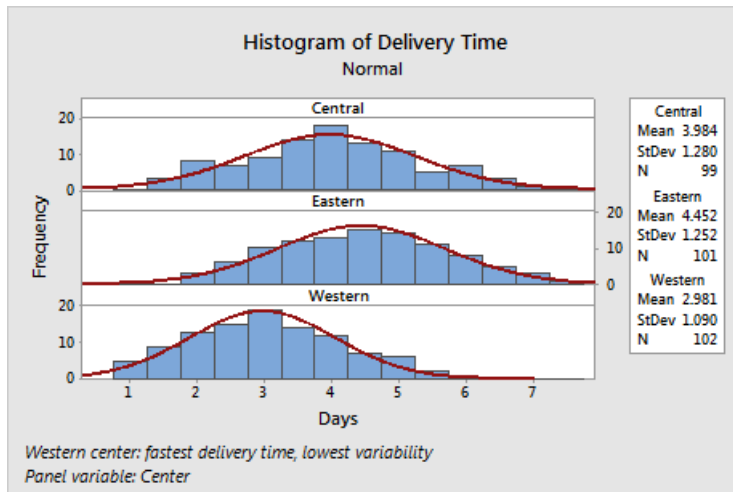
Interpret the results

The paneled histogram now has a more descriptive title and a footnote that provides a brief interpretation of the results.

Examine relationships between two variables

Graphs can help you identify whether relationships exist between variables, and the strength of any relationships. Knowing the relationship between variables can help you determine which variables are important to analyze and which additional analyses to choose.

Because each shipping center serves a region, you suspect that distance to delivery location does not greatly affect delivery time. To verify this suspicion and to eliminate distance as a potentially important factor, you examine the relationship between delivery time and delivery distance for each center.

Create a scatterplot with groups

To examine the relationship between two variables, you use a scatterplot. You can choose a scatterplot from the Graph menu or you can use the Minitab Assistant. The Assistant guides you through your analyses and helps you interpret the results with confidence. The Assistant can be used for most basic statistical tests, graphs, quality analyses, and DOE (design of experiments).

Use the Assistant in the following situations:

* You need assistance to choose the correct tool for an analysis.
* You want dialog boxes that have less technical terminology and that are easier to complete.
* You want Minitab to check the analysis assumptions for you.
* You want output that is more graphical and explains in detail how to interpret your results.

1. Choose **Assistant** > **Graphical Analysis**.
2. Under **Graph relationships between variables**, click **Scatterplot (groups)**.
3. In **Y column**, enter *Days*.
4. In **X column**, enter *Distance*.

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5.   From **Number of X columns**, select **1**.
6.   In **X1**, enter *Center*.
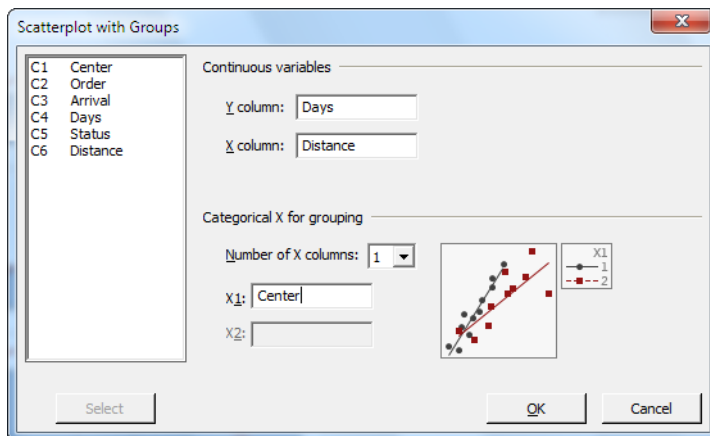
7.   Click **OK**.

Summary report

The summary report contains scatterplots of days versus distance by shipping center overlaid on the same graph. This report also provides smaller scatterplots for each shipping center.
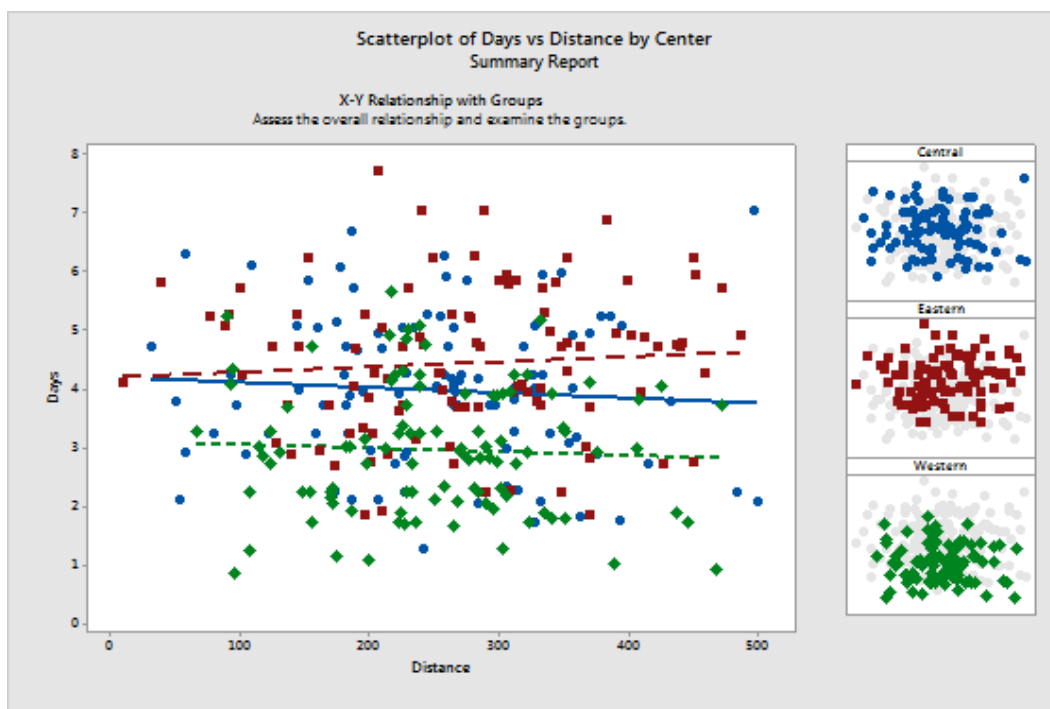
Diagnostic report

The diagnostic report provides guidance on possible patterns in your data. The points on the scatterplot show no apparent relationship between days and distance. The fitted regression line for each center is relatively flat, which indicates that the proximity of a delivery location to a shipping center does not affect the delivery time.

Scatterplot of Days vs Distance by Center
Diagnostic Report

Examine the overall relationship between the process input (X) and the process output (Y) and the X-Y relationship for each group.
• Determine whether the data appear to follow an overall pattern across all groups. The more closely the data fits the pattern, the stronger the relationship between X and Y.
• Identify differences in the X-Y relationship between groups, such as changes in the slope or location of the fitted lines, or clusters of points in different locations.

Descriptive statistics report
The descriptive statistics report contains descriptive statistics for each shipping center.

Scatterplot of Days vs Distance by Center
Descriptive Statistics Report

Center	N	Days				Distance			
		Mean	StDev	Minimum	Maximum	Mean	StDev	Minimum	Maximum
Central	99	3.9840	1.2798	1.2674	7.0701	253.64	99.797	32	500
Eastern	101	4.4520	1.2524	1.8597	7.7479	275.94	104.77	11	487
Western	102	2.9814	1.0896	0.87083	5.6806	251.63	88.492	68	473

Report card
The report card provides information on how to check for unusual data. The report card also indicates that there appears to be a relationship between the Y variable and the X variables. The Y variable is Days and the X variables are Distance and Center. Recall that the scatterplot indicated that there does not appear to be a relationship between days and distance. However, there may be a relationship between days and shipping center, which you will explore further in the next chapter, Analyzing Data on page 22.

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Arrange multiple graphs on one page

Use Minitab's graph layout tool to arrange multiple graphs on one page. You can add annotations to the layout and edit the individual graphs within the layout.

To show your supervisor the preliminary results of the graphical analysis of the shipping data, arrange the summary report and the paneled histogram on one page.

Create a graph layout

1. Ensure that the scatterplot summary report is active, then choose **Editor** > **Layout Tool**.

A list of all open graphs

Buttons used to move graphs to and from the layout

The next graph to be moved to the layout
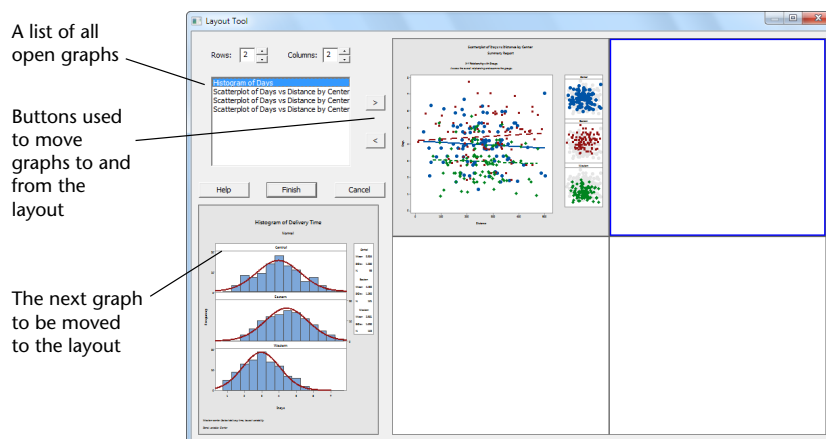
The scatterplot summary report is already included in the layout.

2. To arrange two graphs on one page, in **Rows**, enter *1*.

3. Click the summary report and drag it to the right side of the layout.

4. Click the right arrow button $\boxed{>}$ to place the paneled histogram in the left side of the layout.

5. Click **Finish**.

Graph layout with the paneled histogram and the scatterplot
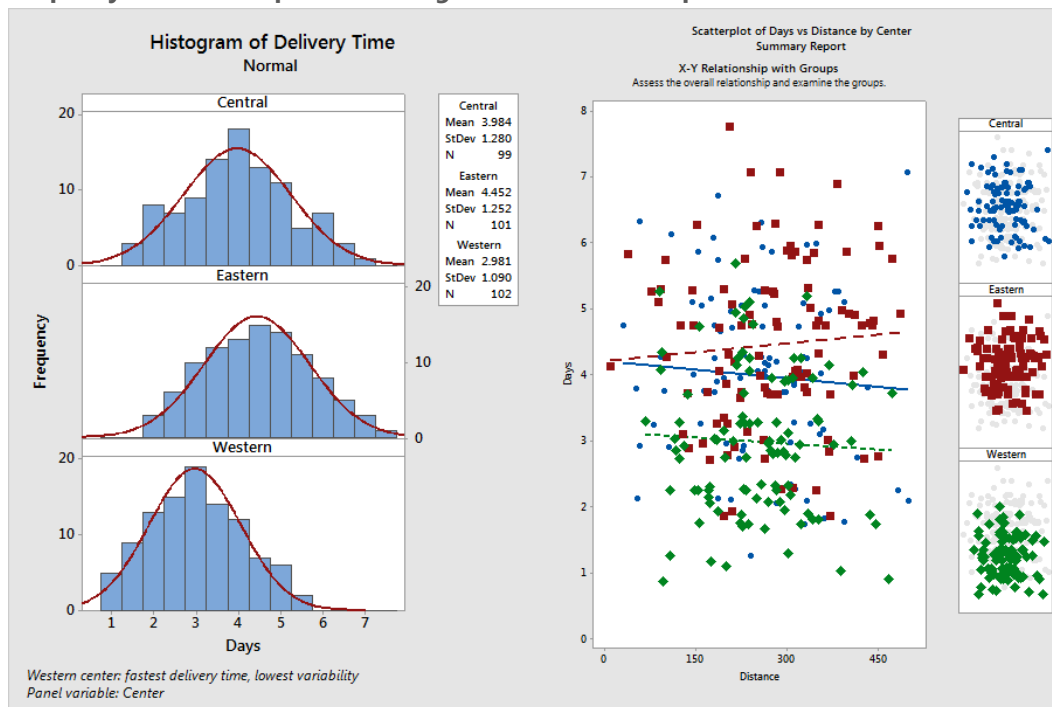
Note   If you edit the data in the worksheet after you create a layout, Minitab cannot automatically update the graphs in the layout. You must recreate the layout with the new graphs.

Annotate the graph layout

You want to add a descriptive title to the graph layout.

1. To ensure that you have the entire graph layout selected, choose **Editor** > **Select Item** > **Graph Region**.

2. Choose **Editor** > **Add** > **Title**.

3. In **Title**, enter *Graphical Analysis of Shipping Data*.

4. Click **OK**.

Graph layout with a new title
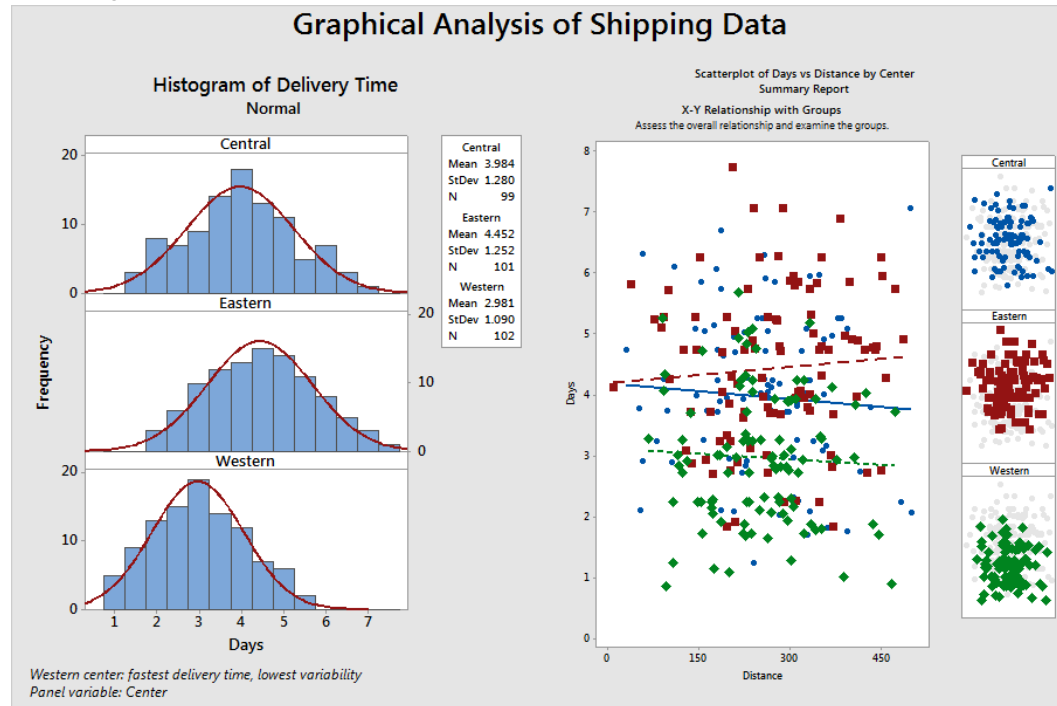
Print the graph layout

You can print any Minitab window, including a graph or a layout.

1. Choose **Window** > **Layout**, and then choose **File** > **Print Graph**.
2. Click **OK**.

Save a Minitab project

Minitab data are saved in worksheets. You can also save Minitab projects, which contain all of your work, including worksheets, Session window output, graphs, history of your session, and dialog box settings.

1. Choose **File** > **Save Project As**.
2. Browse to the folder that you want to save your files in.

3.   In **File name**, enter *MyGraphs*.
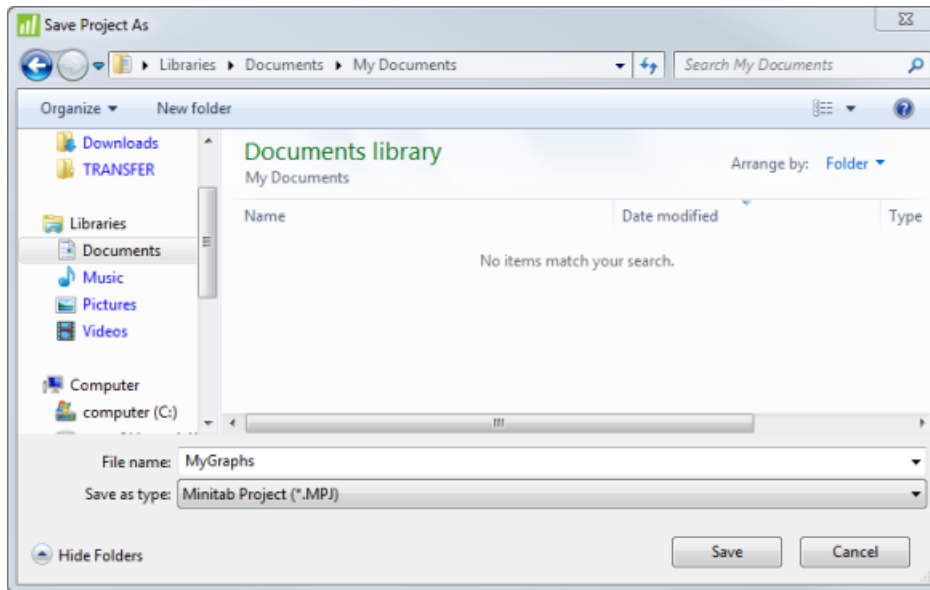
4.   Click **Save**.

In the next chapter

The graphical output indicates that the three shipping centers have different delivery times for book orders. In the next chapter, you display descriptive statistics and perform an ANOVA (analysis of variance) to test whether the differences among the shipping centers are statistically significant.

3 Analyzing Data

Objectives

Overview

The field of statistics provides principles and methods for collecting, summarizing, and analyzing data, and for interpreting the results. You use statistics to describe data and make inferences. Then, you use the inferences to improve processes and products.

Minitab provides many statistical analyses, such as regression, ANOVA, quality tools, and time series. Built-in graphs help you visualize your data and validate your results. In Minitab, you can also display and store statistics and diagnostic measures.

In this chapter, you assess the number of late orders and back orders, and test whether the differences in delivery times between the three shipping centers are statistically significant.

Summarize the data

Descriptive statistics summarize and describe the prominent features of data. Use **Display Descriptive Statistics** to determine how many book orders were delivered on time, how many were late, and how many were initially back ordered for each shipping center.

Display descriptive statistics

1. If you are continuing from the previous chapter, choose **File** > **New** > **Project**. If not, start Minitab.
2. Choose **Help** > **Sample Data**.
3. Double-click the Getting Started folder, then double-click ShippingData.MTW.
4. Choose **Stat** > **Basic Statistics** > **Display Descriptive Statistics**.
5. In **Variables**, enter *Days*.

6. In **By variables (optional)**, enter *Center Status*.
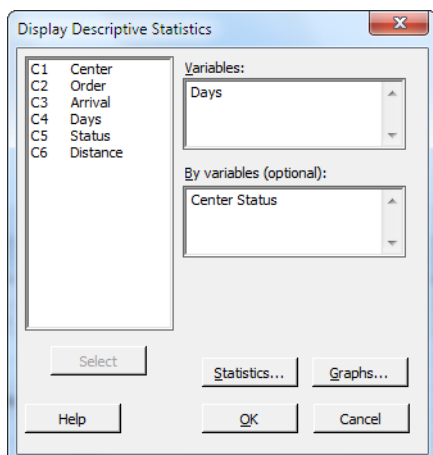
For most Minitab commands, you only need to complete the main dialog box to execute the command. Often, you use sub-dialog boxes to modify the analysis or to display additional output, such as graphs.

7. Click **Statistics**.
8. Deselect **First quartile**, **Median**, **Third quartile**, **N nonmissing**, and **N missing**.
9. Select **N total**.

10. Click **OK** in each dialog box.

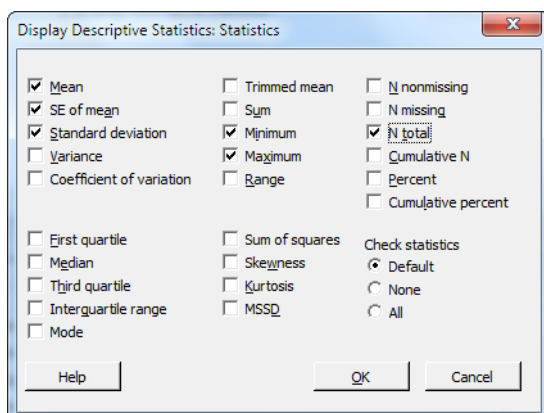> **Note** Changes that you make in the **Statistics** sub-dialog box affect the current session only. To change the default options for future sessions, choose **Tools** > **Options**. Expand **Individual Commands** and select **Display Descriptive Statistics**. Select the statistics that you want to be selected by default. When you open the **Statistics** sub-dialog box again, it displays your new options.

Descriptive Statistics: Days

```
Results for Center = Central
```

Variable	Status	Total Count	Mean	SE Mean	StDev	Minimum	Maximum
Days	Back order	6	*	*	*	*	*
	Late	6	6.431	0.157	0.385	6.078	7.070
	On time	93	3.826	0.119	1.149	1.267	5.983

```
Results for Center = Eastern
```

Variable	Status	Total Count	Mean	SE Mean	StDev	Minimum	Maximum

```
Days      Back order        8      *        *       *        *        *
          Late              9   6.678    0.180   0.541    6.254    7.748
          On time          92   4.234    0.112   1.077    1.860    5.953
```

Results for Center = Western

```
                        Total
Variable  Status        Count   Mean   SE Mean  StDev   Minimum  Maximum
Days      Back order        3      *        *       *        *        *
          On time         102   2.981    0.108   1.090    0.871    5.681
```

Note   The Session window displays text output, which you can edit, add to the ReportPad, and print. For more information about the ReportPad, go to Generating a Report on page 61.

Interpret the results

The Session window displays each center's results separately. Within each center, you can see the number of back orders, late orders, and on-time orders in the Total Count column:

• The Eastern shipping center has the most back orders (8) and late orders (9).

• The Central shipping center has the next most back orders (6) and late orders (6).

• The Western shipping center has the fewest back orders (3) and no late orders.

The Session window output also includes the mean, standard error of the mean, standard deviation, minimum, and maximum of delivery time in days for each center. These statistics do not exist for back orders.

Compare two or more means

One of the most common methods used in statistical analysis is hypothesis testing. Minitab offers many hypothesis tests, including t-tests and ANOVA (analysis of variance). Usually, when you perform a hypothesis test, you assume an initial claim to be true, and then test this claim using sample data.

Hypothesis tests include two hypotheses (claims), the null hypothesis (H_0) and the alternative hypothesis (H_1). The null hypothesis is the initial claim and is often specified based on previous research or common knowledge. The alternative hypothesis is what you believe might be true.

Given the graphical analysis in the previous chapter and the descriptive analysis above, you suspect that the difference in the average number of delivery days across shipping centers is statistically significant. To verify this, you perform a one-way ANOVA, which tests the equality of two or more means. You also perform a Tukey's multiple comparison test to see which shipping center means are different. For this one-way ANOVA, delivery days is the response, and shipping center is the factor.
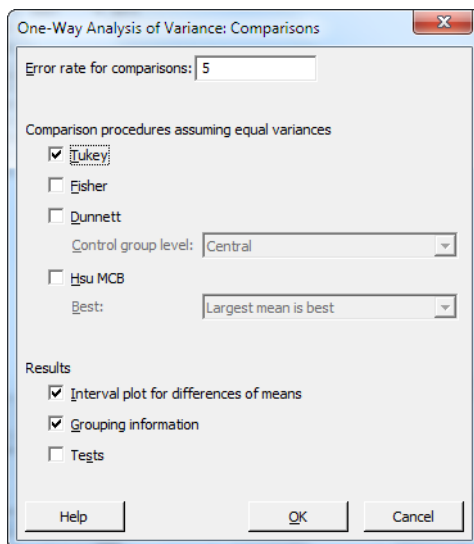
Perform an ANOVA

1.   Choose **Stat** > **ANOVA** > **One-Way**.
2.   Select **Response data are in one column for all factor levels**.

3. In **Response**, enter *Days*. In **Factor**, enter *Center*.
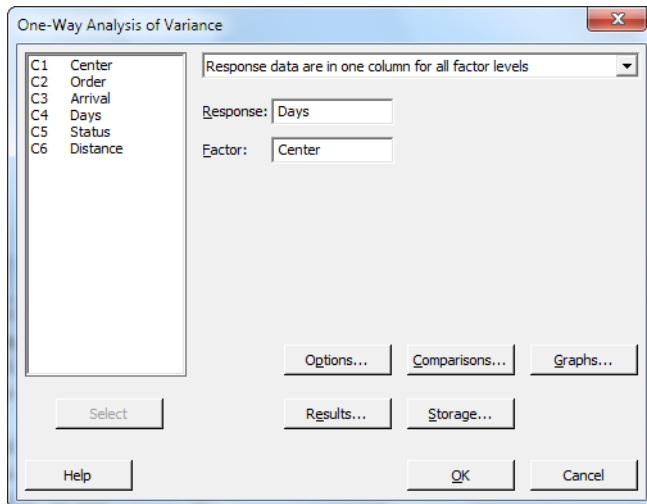
4. Click **Comparisons**.
5. Under **Comparison procedures assuming equal variances**, select **Tukey**.

6. Click **OK**.
7. Click **Graphs**.

   For many statistical commands, Minitab includes graphs that help you interpret the results and assess the validity of statistical assumptions. These graphs are called built-in graphs.

8. Under **Data plots**, select **Interval plot**, **Individual value plot**, and **Boxplot of data**.

9. Under **Residual plots**, select **Four in one**.
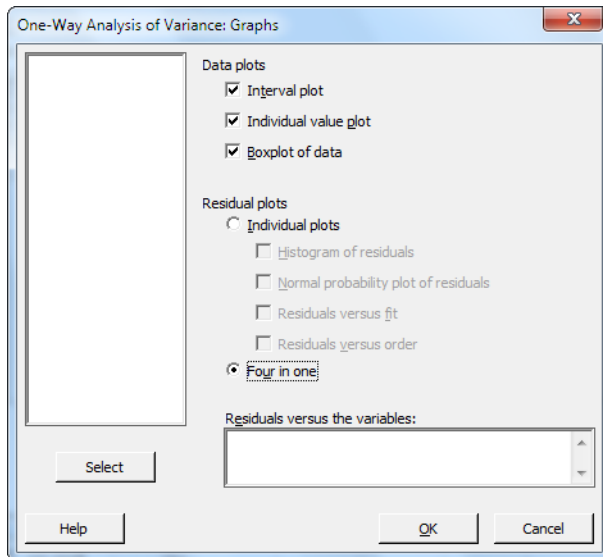
10. Click **OK** in each dialog box.

    One-way ANOVA: Days versus Center

    ```
    Method

    Null hypothesis         All means are equal
    Alternative hypothesis  At least one mean is different
    Significance level      α = 0.05
    Rows unused             17

    Equal variances were assumed for the analysis.


    Factor Information

    Factor   Levels   Values
    Center        3   Central, Eastern, Western


    Analysis of Variance

    Source    DF   Adj SS   Adj MS   F-Value   P-Value
    Center     2    114.6   57.317     39.19     0.000
    Error    299    437.3    1.462
    Total    301    551.9


    Model Summary

         S    R-sq   R-sq(adj)   R-sq(pred)
    1.20933  20.77%      20.24%       19.17%


    Means

    Center    N   Mean   StDev        95% CI
    Central  99  3.984   1.280  (3.745, 4.223)
    ```

```
Eastern  101  4.452  1.252  (4.215, 4.689)
Western  102  2.981  1.090  (2.746, 3.217)


Pooled StDev = 1.20933
```

Tukey Pairwise Comparisons

```
Grouping Information Using the Tukey Method and 95% Confidence

Center     N   Mean  Grouping
Eastern  101  4.452  A
Central   99  3.984    B
Western  102  2.981      C

Means that do not share a letter are significantly different.
```
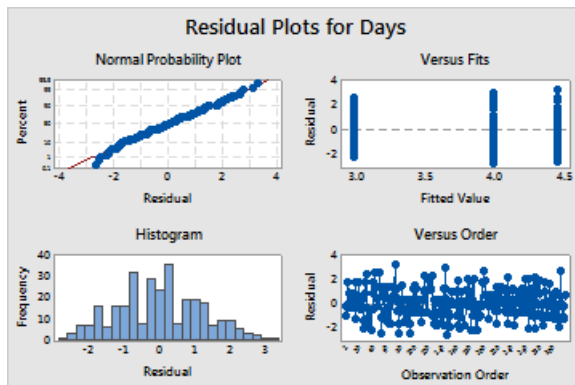
Interpret the Session window output

The decision-making process for a hypothesis test is based on the p-value, which indicates the probability of falsely rejecting the null hypothesis when it is really true.
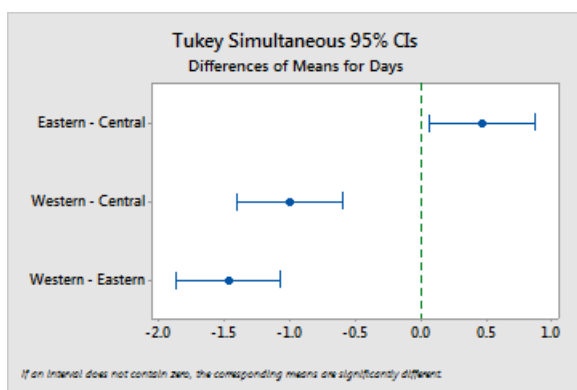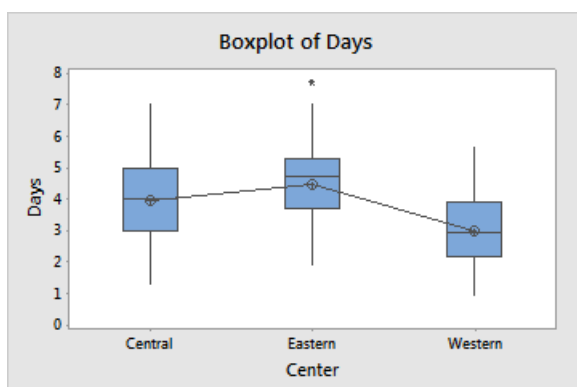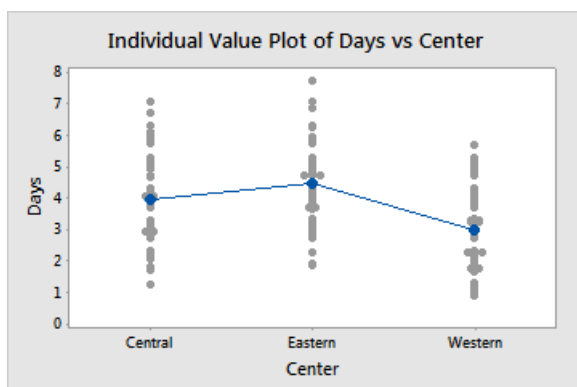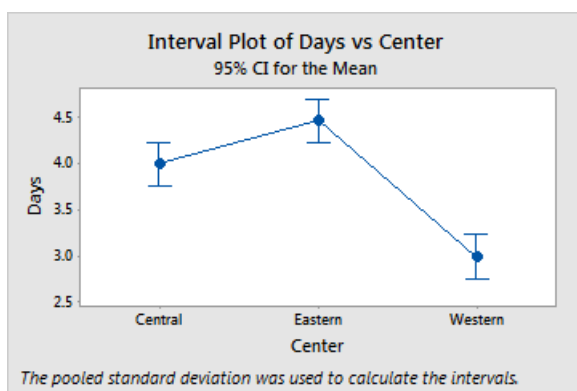
- If the p-value is less than or equal to a predetermined significance level (denoted by α or alpha), then you reject the null hypothesis and claim support for the alternative hypothesis.

- If the p-value is greater than α, then you fail to reject the null hypothesis and cannot claim support for the alternative hypothesis.

With an α of 0.05, the p-value (0.000) in the Analysis of Variance table provides enough evidence to conclude that the average delivery times for at least two of the shipping centers are significantly different.

The results of the Tukey's test are included in the grouping information table, which highlights the significant and non-significant comparisons. Because each shipping center is in a different group, all shipping centers have average delivery times that are significantly different from each other.

ANOVA graphs

Residual Plots for Days

Interval Plot of Days vs Center
95% CI for the Mean

The pooled standard deviation was used to calculate the intervals.

Individual Value Plot of Days vs Center

Boxplot of Days

Tukey Simultaneous 95% CIs
Differences of Means for Days

If an interval does not contain zero, the corresponding means are significantly different.

Interpret the ANOVA graphs

Minitab produced the following graphs:

- Four-in-one residual plot
- Interval plot
- Individual value plot
- Boxplot
- Tukey 95% confidence interval plot

You examine the residual plots first. Then, you examine the interval plot, individual value plot, and boxplot together to assess the equality of the means. Finally, you examine the Tukey 95% confidence interval plot to determine statistical significance.

Interpret the residual plots

Use residual plots, which are available with many statistical commands, to verify statistical assumptions.

Normal Probability Plot
   Use this plot to detect nonnormality. Points that approximately follow a straight line indicate that the residuals are normally distributed.

Histogram
   Use this plot to detect multiple peaks, outliers, and nonnormality. Look for a normal histogram, which is approximately symmetric and bell-shaped.

Versus Fits
   Use this plot to detect nonconstant variance, missing higher-order terms, and outliers. Look for residuals that are scattered randomly around zero.

Versus Order
   Use this plot to detect the time dependence of the residuals. Inspect the plot to ensure that the residuals display no obvious pattern.

For the shipping data, the four-in-one residual plots indicate no violations of statistical assumptions. The one-way ANOVA model fits the data relatively well.

Note   In Minitab, you can display each of the residual plots on a separate page.

Interpret the interval plot, individual value plot, and boxplot

Examine the interval plot, individual value plot, and boxplot. Each graph indicates that the delivery time varies by shipping center, which is consistent with the histograms from the previous chapter. The boxplot for the Eastern shipping center has an asterisk. The asterisk identifies an outlier, which is an order that has an unusually long delivery time.

Examine the interval plot again. The interval plot displays 95% confidence intervals for each mean. Hold the pointer over the points on the graph to view the means. Hold the pointer over the interval bars to view the 95% confidence intervals. The interval plot shows that the Western shipping center has the fastest mean delivery time (2.981 days) and a confidence interval of 2.75 to 3.22 days.

Interpret the Tukey 95% confidence interval plot

The Tukey 95% confidence interval plot is the best graph to use to determine the likely ranges for the differences and to assess the practical significance of those differences. The Tukey confidence intervals show the following pairwise comparisons:

Minitab >

- Eastern shipping center mean minus Central shipping center mean
- Western shipping center mean minus Central shipping center mean
- Western shipping center mean minus Eastern shipping center mean

Hold the pointer over the points on the graph to view the middle, upper, and lower estimates. The interval for the Eastern minus Central comparison is 0.068 to 0.868. That is, the mean delivery time of the Eastern shipping center minus the mean delivery time of the Central shipping center is between 0.068 and 0.868 days. The Eastern shipping center's deliveries take significantly longer than the Central shipping center's deliveries. You interpret the other Tukey confidence intervals similarly. Also, notice the dashed line at zero. If an interval does not contain zero, the corresponding means are significantly different. Therefore, all the shipping centers have significantly different average delivery times.

Access StatGuide

Suppose you want more information about how to interpret a one-way ANOVA, specifically Tukey's multiple comparison method. Minitab StatGuide provides detailed information about the Session window output and graphs for most statistical commands.

1. Put your cursor anywhere in the one-way ANOVA Session window output.
2. On the Standard toolbar, click the **StatGuide** button Σ.
3. In the **Contents** pane, choose **ANOVA** > **One-Way** > **Tukey's method**.

Save the project

Save all your work in a Minitab project.

1. Choose **File** > **Save Project As**.
2. Navigate to the folder that you want to save your files in.
3. In **File name**, enter *MyStats*.
4. Click **Save**.

Use Minitab's Project Manager

Now you have a Minitab project that contains a worksheet, several graphs, and Session window output from your analyses. The Project Manager helps you navigate, view, and manipulate parts of your Minitab project.
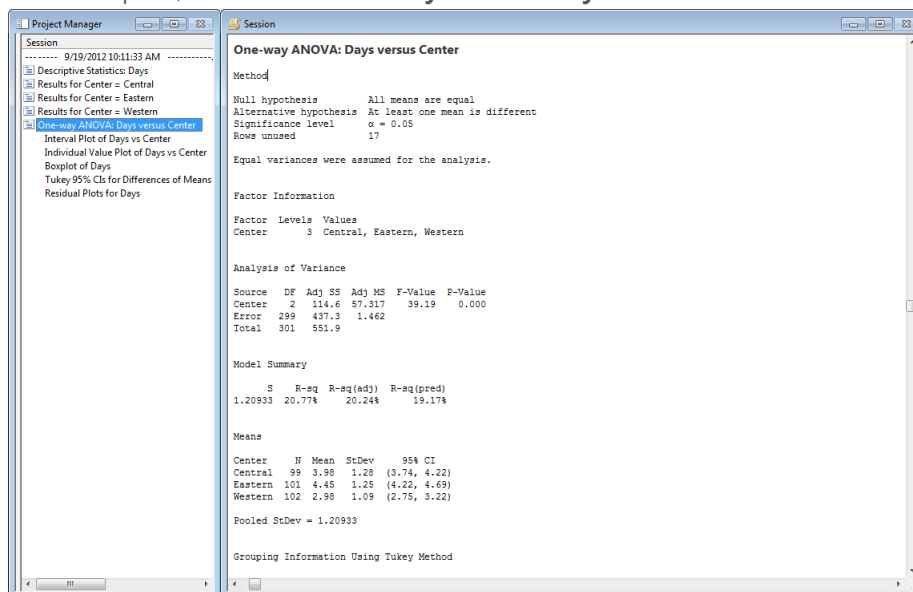
Use the Project Manager to view the statistical analyses that you just performed.

View the Session window output

Use the Project Manager to review the one-way ANOVA Session window output.

1. On the Project Manager toolbar, click the **Show Session Folder** button .

2. In the left pane, double-click **One-way ANOVA: Days versus Center**.

The Project Manager displays the one-way ANOVA session window output in the right pane.

View the graphs

You want to view the boxplot again. You can double-click **Boxplot of Days** in the **Session** folder or use the **Show Graphs Folder** button on the toolbar.

1. On the Project Manager toolbar, click the **Show Graphs Folder** button.
2. In the left pane, double-click **Boxplot of Days**.
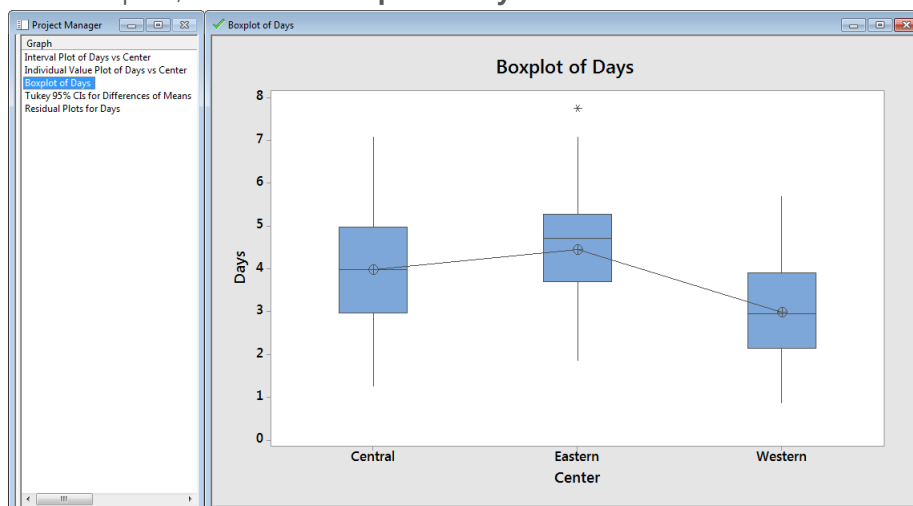
The Project Manager displays the boxplot in the Graph window.

In the next chapter

The descriptive statistics and ANOVA results indicate that the Western shipping center has the fewest late orders and back orders, and has the shortest delivery time. In the next chapter, you create a control chart and perform a capability

analysis to investigate whether the Western shipping center's process is stable over time and is capable of operating within specifications.

4 Assessing Quality

Objectives

- Create and interpret control charts on page 34
- Add stages to a control chart on page 35
- Update a control chart on page 36
- Add date/time labels to a control chart on page 38
- Perform and interpret a capability analysis on page 39

Overview

Quality is the degree to which products or services meet the needs of customers. Common goals for quality professionals include reducing defect rates, manufacturing products within specifications, and standardizing delivery time.

Minitab offers many methods to help you assess quality in an objective, quantitative way. These methods include control charts, quality planning tools, measurement systems analysis (gage R&R studies), process capability, and reliability/survival analysis. This chapter focuses on control charts and process capability.

You can customize Minitab's control charts in the following ways:

- Automatically update the chart after you add or change data.
- Choose how to estimate parameters and control limits.
- Display tests for special causes and historical stages.
- Customize the chart, such as adding a reference line, changing the scale, and modifying titles.

You can customize control charts when you create them or later.

With Minitab's capability analysis, you can do the following:

- Analyze process data from many different distributions, including normal, exponential, Weibull, gamma, Poisson, and binomial.
- Display charts to verify that the process is in control and that the data follow the chosen distribution.

The graphical and statistical analyses that you performed in the previous chapter show that the Western shipping center has the fastest delivery time. In this chapter, you determine whether the Western shipping center's process is in control and is capable of operating within specifications.

Assess process stability

Unusual patterns in your data indicate the presence of special-cause variation, that is, variation that is not a normal part of the process. Use control charts to detect special-cause variation and to assess process stability over time.

Minitab control charts display process statistics. Process statistics include subgroup means, individual observations, weighted statistics, and numbers of defects. Minitab control charts also display a center line and control limits. The center line is the average value of the quality statistic that you choose to assess. If a process is in control, the points will vary randomly around the center line. The control limits are calculated based on the expected random variation

in the process. The upper control limit (UCL) is 3 standard deviations above the center line. The lower control limit (LCL) is 3 standard deviations below the center line. If a process is in control, all points on the control chart are between the upper and lower control limits.

For all control charts, you can modify Minitab's default chart specifications. For example, you can define the estimation method for the process standard deviation, specify the tests for special causes, and display historical stages.

Create an Xbar-S chart

Create an Xbar-S chart to assess both the mean and variability of the process. This control chart displays an Xbar chart and an S chart on the same graph. Use an Xbar-S chart when your subgroups contain 9 or more observations.

To determine whether the delivery process is stable over time, the manager of the Western shipping center randomly selected 10 samples for 20 days.

1. If you are continuing from the previous chapter, choose **File** > **New** > **Project**. If not, start Minitab.
2. Choose **Help** > **Sample Data**.
3. Double-click the Getting Started folder, then double-click Quality.MTW.
4. Choose **Stat** > **Control Charts** > **Variables Charts for Subgroups** > **Xbar-S**.
5. From the drop-down list, select **All observations for a chart are in one column**, then enter *Days*.
6. In **Subgroup sizes**, enter *Date*.
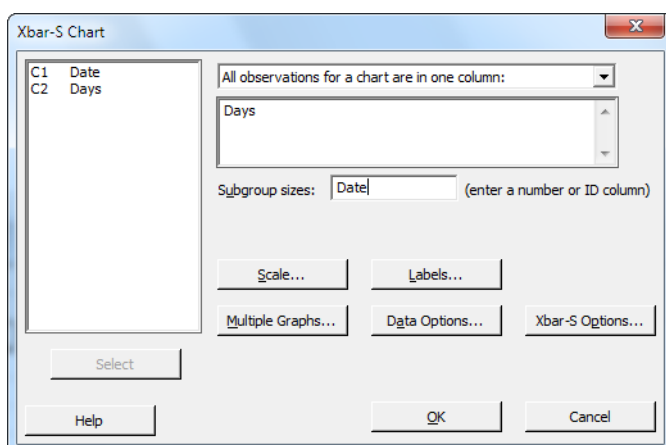
   To create a control chart, you only need to complete the main dialog box. However, you can click any button to select options to customize your chart.

7. Click **OK**.

Xbar-S chart
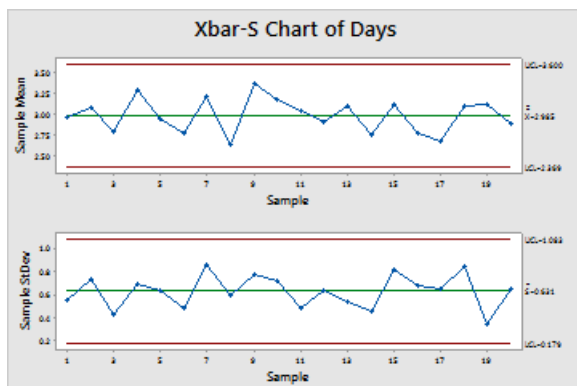
| **Tip** | Hold the pointer over points on a control chart or graph to view information about the data. |

Interpret the Xbar-S chart

All of the points on the control chart are within the control limits. Thus, the process mean and process standard deviation appear to be stable or in control. The process mean ($\overline{\overline{X}}$) is 2.985. The average standard deviation ($\overline{S}$) is 0.631.

Add stages to the control chart

You can use stages on a control chart to show how a process changes over specific periods of time. At each stage, Minitab recalculates the center line and control limits.

The manager of the Western shipping center made a process change on March 15. You want to determine whether the process was stable before and after this process change.

1. Press **Ctrl+E** to open the last dialog box, or choose **Stat** > **Control Charts** > **Variables Charts for Subgroups** > **Xbar-S**.
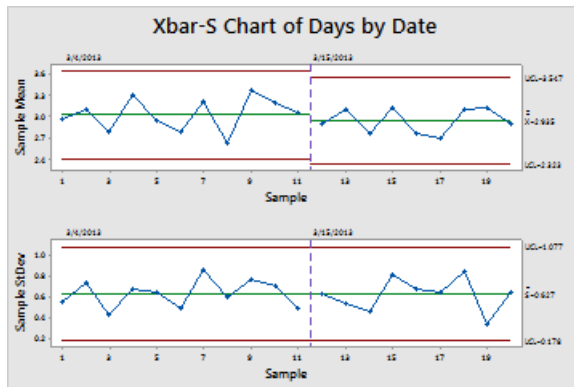
    | **Tip** | Minitab saves your dialog box settings with your project. To reset a dialog box, press **F3**. |

2. Click **Xbar-S Options**.
3. On the **Stages** tab, in **Define stages (historical groups) with this variable**, enter *Date*.
4. Under **When to start a new stage**, select **With the first occurrence of these values**, and enter *3/15/2013*.
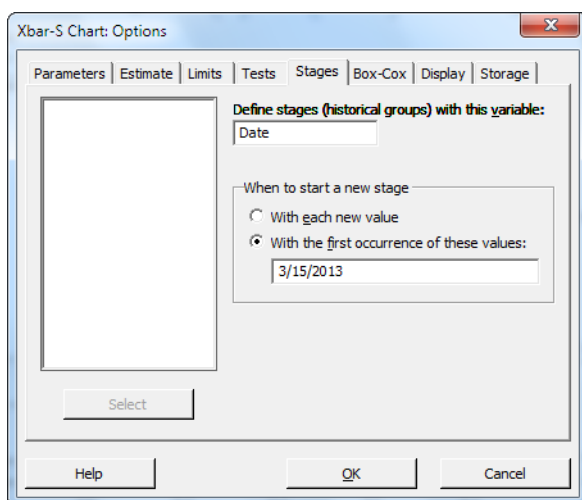
5. Click **OK** in each dialog box.

Xbar-S chart with stages

Interpret the results

All the points on the control chart are within the control limits before and after the process change. For the second stage, the process mean ($\overline{\overline{X}}$) is 2.935 and the average standard deviation ($\overline{S}$) is 0.627.

Note   By default, Minitab displays the control limits and center line labels for the most recent stage. To display labels for all stages, click **Xbar-S Options**. On the **Display** tab, under **Other**, select **Display control limit / center line labels for all stages**.

Add more data and update the control chart

When your data change, you can update any control chart or graph (except stem-and-leaf plot) without re-creating the graph.

After you create the Xbar-S chart, the manager of the Western shipping center gives you more data, which was collected on 3/24/2013. Add the data to the worksheet and update the control chart.

Add more data to the worksheet

You need to add date/time data to C1 and numeric data to C2.

1.   Click the worksheet to make it active.
2.   Click any cell in C1, and then press **End** to go to the bottom of the worksheet.

3. To add the date, 3/24/2013, to rows 201–210:
   a. Enter *3/24/2013* in row 201 in C1.
   b. Select the cell that contains 3/24/2013, and point to the Autofill handle in the lower-right corner of the cell. When the pointer becomes a cross symbol (+), press **Ctrl** and drag the pointer to row 210 to fill the cells with the repeated date value. When you press and hold **Ctrl**, a superscript cross appears above the Autofill cross symbol ($+^+$). The superscript cross indicates that repeated values, instead of sequential values, will be added to the cells.

4. Add the following data to C2, starting in row 201:

   3.60 2.40 2.80 3.21 2.40 2.75 2.79 3.40 2.58 2.50

   As you enter data, press **Enter** to move to the next cell down. If the data-entry direction arrow points to the right, click the arrow so that it points down.

5. Verify that you entered the data correctly.

Update the control chart

1. Right-click the Xbar-S chart, then choose **Update Graph Now**.

Updated Xbar-S chart showing the new subgroup
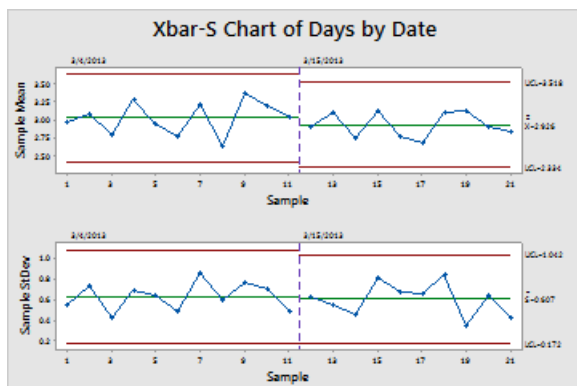
The Xbar-S chart now includes the new subgroup. The mean ($\overline{\overline{X}}$ = 2.926) and standard deviation ($\overline{S}$ = 0.607) changed slightly, but the process still appears to be in control.

Note   To update all graphs and control charts automatically, choose **Tools** > **Options**. Expand **Graphics**, then select **Other Graphics Options**. Select **On creation, set graph to update automatically when data change**.

Change the x-axis labels to dates

By default, the subgroups on Xbar-S charts are labeled in consecutive numeric order. You can edit the x-axis to display dates instead.

1.   Double-click the x-axis on the Xbar chart (the top chart).
2.   On the **Time** tab, under **Time Scale**, select **Stamp**. In **Stamp columns (1-3, innermost first)**, enter *Date*.
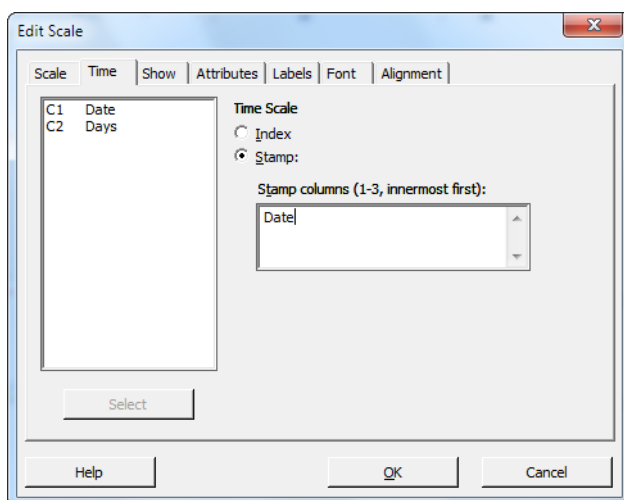
3.   Click **OK**.
4.   Repeat for the x-axis on the S chart.

Xbar-S chart with edited x-axes
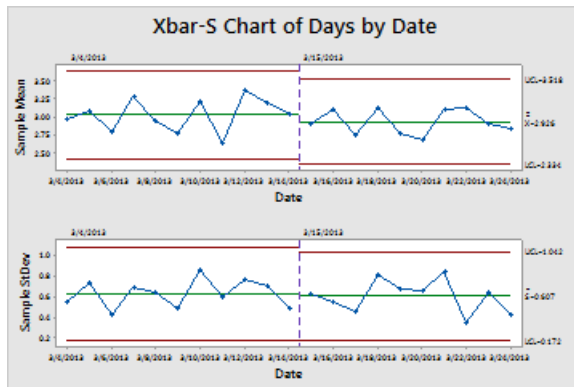
Interpret the results

The x-axis for each chart now shows the dates instead of the subgroup numbers.

Assess process capability

After you determine that a process is in statistical control, you want to know whether that process is capable. A process is capable if it meets specifications and produces good parts or results. You assess process capability by comparing the spread of the process variation to the width of the specification limits.

Important   Do not assess the capability of a process that is not in control because the estimates of process capability might be incorrect.

Capability indices, or statistics, are a simple way of assessing process capability. Because capability indices reduce process information to single numbers, comparing one process to another is easy.

Perform a capability analysis

Now that you know that the delivery process is in control, perform a capability analysis to determine whether the delivery process is within specification limits and produces acceptable delivery times. The upper specification limit (USL) is 6 because the manager of the Western shipping center considers an order to be late if it is delivered after 6 days. The manager does not specify a lower specification limit (LSL). The distribution is approximately normal, so you can use a normal capability analysis.
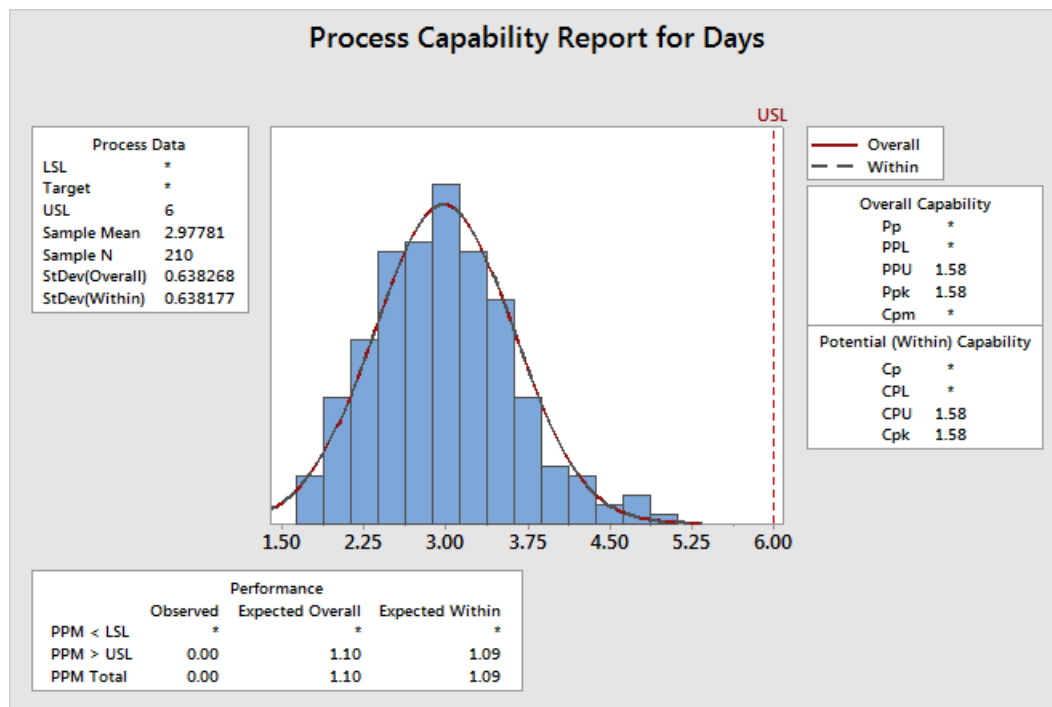
1. Choose **Stat** > **Quality Tools** > **Capability Analysis** > **Normal**.
2. Under **Data are arranged as**, select **Single column**. Enter *Days*.
3. In **Subgroup size**, enter *Date*.

4. In **Upper spec**, enter *6*.
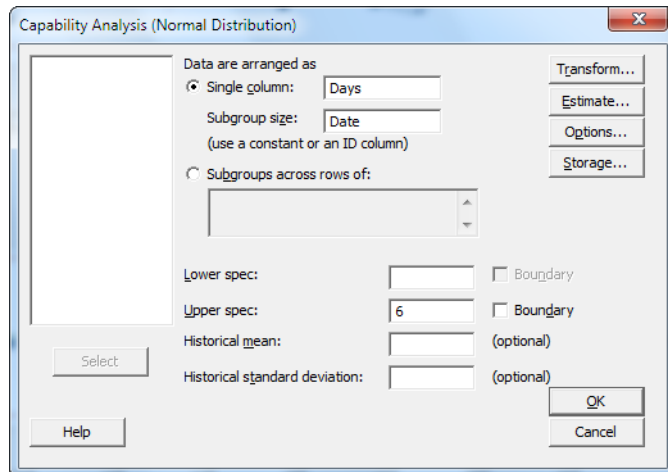
5. Click **OK**.

Capability analysis of the delivery process

Interpret the results

Cpk is a measure of potential process capability. Ppk is a measure of overall process capability. Both Cpk and Ppk are greater than 1.33, which is a generally accepted minimum value. These statistics indicate that the Western shipping center's process is capable and that the shipping center delivers orders in an acceptable amount of time.

Save the project

Save all your work in a Minitab project.

1.   Choose **File** > **Save Project As**.
2.   Browse to the folder that you want to save your files in.
3.   In **File name**, enter *MyQuality*.
4.   Click **Save**.

In the next chapter

The quality analysis indicates that the Western shipping center's process is in control and is capable of meeting specification limits. In the next chapter, you design an experiment and analyze the results to investigate ways to further improve the delivery process at the Western shipping center.

5 Designing an Experiment

Objectives

Overview

DOE (design of experiments) helps you investigate the effects of input variables (factors) on an output variable (response) at the same time. These experiments consist of a series of runs, or tests, in which purposeful changes are made to the input variables. Data are collected at each run. You use DOE to identify the process conditions and product components that affect quality, and then determine the factor settings that optimize results.

Minitab offers four types of designs: factorial designs, response surface designs, mixture designs, and Taguchi designs (also called Taguchi robust designs). The steps you follow in Minitab to create, analyze, and visualize a designed experiment are similar for all types. After you perform the experiment and enter the results, Minitab provides several analytical tools and graph tools to help you understand the results. This chapter demonstrates the typical steps to create and analyze a factorial design. You can apply these steps to any design that you create in Minitab.

Minitab DOE commands include the following features:
- Catalogs of designed experiments to help you create a design
- Automatic creation and storage of your design after you specify its properties
- Display and storage of diagnostic statistics to help you interpret the results
- Graphs to help you interpret and present the results

In this chapter, you investigate two factors that might decrease the time that is needed to prepare an order for shipment: the order-processing system and the packing procedure.

The Western center has a new order-processing system. You want to determine whether the new system decreases the time that is needed to prepare an order. The center also has two different packing procedures. You want to determine which procedure is more efficient. You decide to perform a factorial experiment to test which combination of factors enables the shortest time that is needed to prepare an order for shipment.

Create a designed experiment

Before you can enter or analyze DOE data in Minitab, you must first create a designed experiment in the worksheet. Minitab offers a variety of designs.

Factorial
Includes 2-level full designs, 2-level fractional designs, split-plot designs, and Plackett-Burman designs.

Response surface

Includes central composite designs and Box-Behnken designs.

Mixture

Includes simplex centroid designs, simplex lattice designs, and extreme vertices designs.

Taguchi

Includes 2-level designs, 3-level designs, 4-level designs, 5-level designs, and mixed-level designs.

You choose the appropriate design based on the requirements of your experiment. Choose the design from the **Stat** > **DOE** menu. You can also open the appropriate toolbar by choosing **Tools** > **Toolbars**. After you choose the design and its features, Minitab creates the design and stores it in the worksheet.

Select a design

You want to create a factorial design to examine the relationship between two factors, order-processing system and packing procedure, and the time that is needed to prepare an order for shipping.

1. Choose **File** > **New** > **Project**.
2. Choose **Stat** > **DOE** > **Factorial** > **Create Factorial Design**.
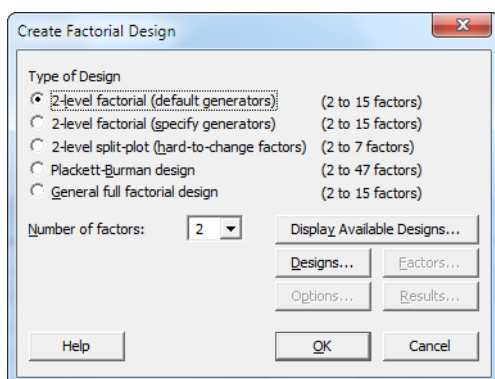

When you create a design in Minitab, only two buttons are enabled, **Display Available Designs** and **Designs**. The other buttons are enabled after you complete the **Designs** sub-dialog box.

3. Click **Display Available Designs**.
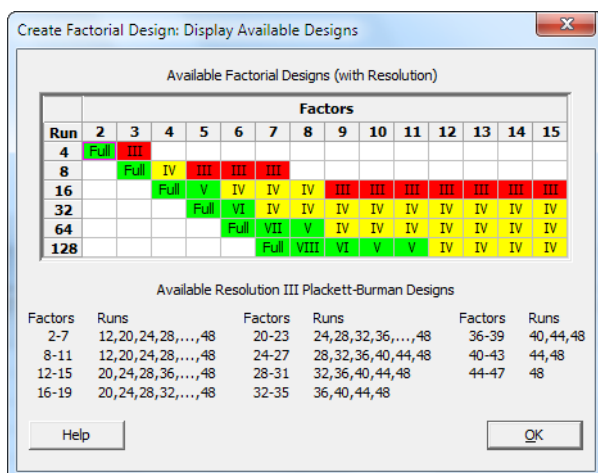
For most design types, Minitab displays all the possible designs and the number of required experimental runs in the **Display Available Designs** dialog box.

4. Click **OK** to return to the main dialog box.
5. Under **Type of Design**, select **2-level factorial (default generators)**.
6. From **Number of factors**, select **2**.
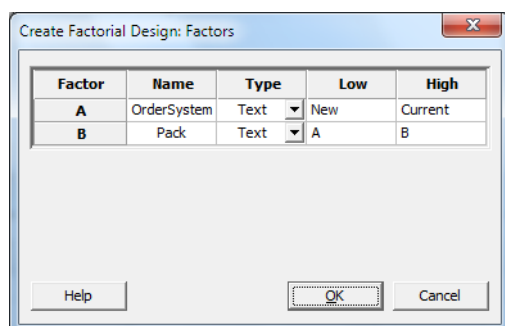7. Click **Designs**.
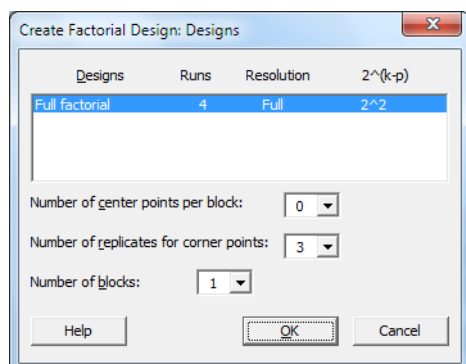
The area at the top of the sub-dialog box shows available designs for the design type and the number of factors that you chose. In this example, because you are performing a factorial design with two factors, you have only one option, a full factorial design with four experimental runs. A 2-level design with two factors has 2^2 (four) possible factor combinations.

8. From **Number of replicates for corner points**, selecting **3**.
9. Click **OK** to return to the main dialog box.

All the buttons are now enabled.

Enter the factor names and set the factor levels

Minitab uses the factor names as the labels for the factors on the analysis output and graphs. If you do not enter factor levels, Minitab sets the low level at −1 and the high level at 1.

1. Click **Factors**.
2. In the row for **Factor A**, under **Name**, enter *OrderSystem*. Under **Type**, select **Text**. Under **Low**, enter *New*. Under **High**, enter *Current*.
3. In the row for **Factor B**, under **Name**, enter *Pack*. Under **Type**, select **Text**. Under **Low**, enter *A*. Under **High**, enter *B*.


4. Click **OK** to return to the main dialog box.

Randomize and store the design

By default, Minitab randomizes the run order of all design types, except Taguchi designs. Randomization helps ensure that the model meets certain statistical assumptions. Randomization can also help reduce the effects of factors that are not included in the study.

Setting the base for the random data generator ensures that you obtain the same run order each time you create the design.

1. Click **Options**.
2. In **Base for random data generator**, enter *9*.
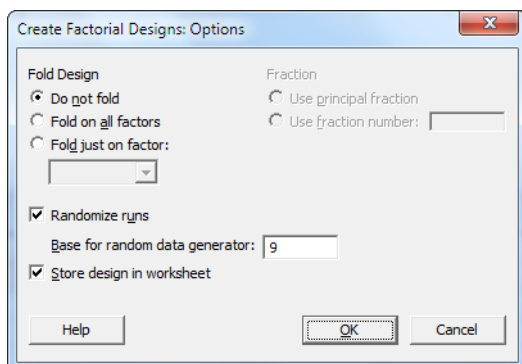
3. Verify that **Store design in worksheet** is selected.
4. Click **OK** in each dialog box.

View the design

Each time you create a design, Minitab stores design information and factors in worksheet columns.

1. Maximize the worksheet to see the structure of a typical design. You can also open the worksheet DOE.MTW in the Getting Started folder. DOE.MTW includes the design and the response data.

The RunOrder column (C2) indicates the order to collect data. If you do not randomize the design, the StdOrder and RunOrder columns are the same.

In this example, because you did not add center points or put runs into blocks, Minitab sets all the values in C3 and C4 to 1. The factors that you entered are stored in columns C5 (OrderSystem) and C6 (Pack).

Note   You can use **Stat** > **DOE** > **Display Design** to switch between a random display and a standard-order display, and between a coded display and an uncoded display. To change the factor settings or names, use **Stat** > **DOE** > **Modify Design**. If you need to change only the factor names, you can enter them directly in the worksheet.

Enter data into the worksheet

After you perform the experiment and collect the data, you can enter the data into the worksheet.

The characteristic that you measure is called a response. In this example, the response that you measure is the number of hours that are needed to prepare an order for shipment. You obtain the following data from the experiment:

14.72 9.62 13.81 7.97 12.52 13.78 14.64 9.41 13.89 13.89 12.57 14.06

1. In the worksheet, click the column name cell of C7 and enter *Hours*.
2. In the Hours column, enter the data as shown below.

	C1	C2	C3	C4	C5-T	C6-T	C7
	StdOrder	RunOrder	CenterPt	Blocks	OrderSystem	Pack	Hours
1	2	1	1	1	Current	A	14.72
2	11	2	1	1	New	B	9.62
3	4	3	1	1	Current	B	13.81
4	3	4	1	1	New	B	7.97
5	1	5	1	1	New	A	12.52
6	12	6	1	1	Current	B	13.78
7	10	7	1	1	Current	A	14.64
8	7	8	1	1	New	B	9.41
9	6	9	1	1	Current	A	13.89
10	8	10	1	1	Current	B	13.89
11	5	11	1	1	New	A	12.57
12	9	12	1	1	New	A	14.06

You can enter data in any columns except in columns that contain design information. You can also enter multiple responses for an experiment, one response per column.

Note To print a data collection form, click in the worksheet and choose **File** > **Print Worksheet**. Verify that **Print Grid Lines** is selected. Use the form to record measurements during the experiment.
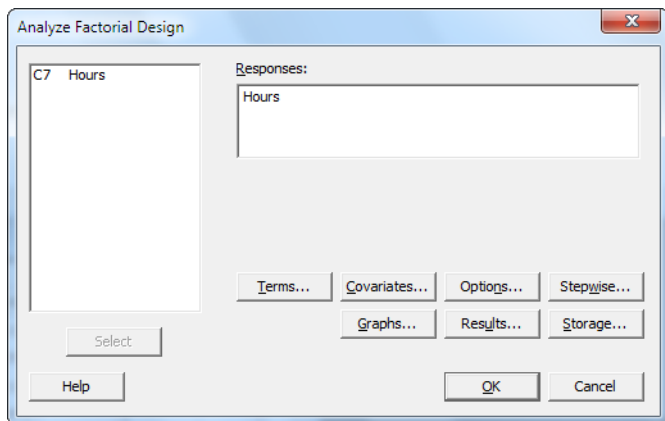
Analyze the design

After you create a design and enter the response data, you can fit a model to the data and generate graphs to assess the effects. Use the results from the fitted model and graphs to determine which factors are important to reduce the number of hours that are needed to prepare an order for shipment.
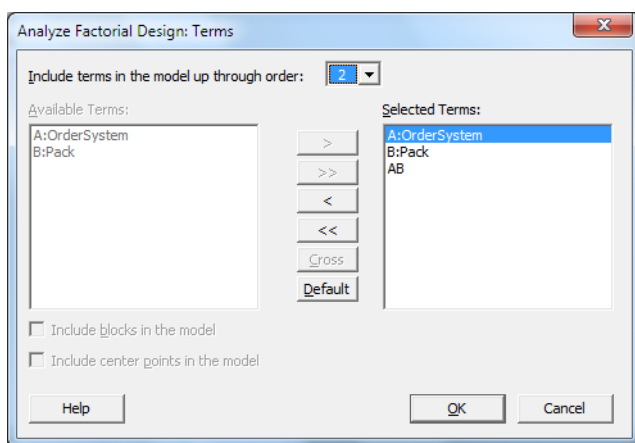
Fit a model

Because the worksheet contains a factorial design, Minitab enables the **DOE** > **Factorial** menu commands, **Analyze Factorial Design** and **Factorial Plots**. In this example, you fit the model first.

1. Choose **Stat** > **DOE** > **Factorial** > **Analyze Factorial Design**.

2. In **Responses**, enter *Hours*.

3. Click **Terms**. Verify that **A:OrderSystem**, **B:Pack**, and **AB** are in the **Selected Terms** box.

When you analyze a design, always use the **Terms** sub-dialog box to select the terms to include in the model. You can add or remove factors and interactions by using the arrow buttons. Use the check boxes to include blocks and center points in the model.

4. Click **OK**.
5. Click **Graphs**.

6. Under **Effects Plots**, select **Pareto** and **Normal**.
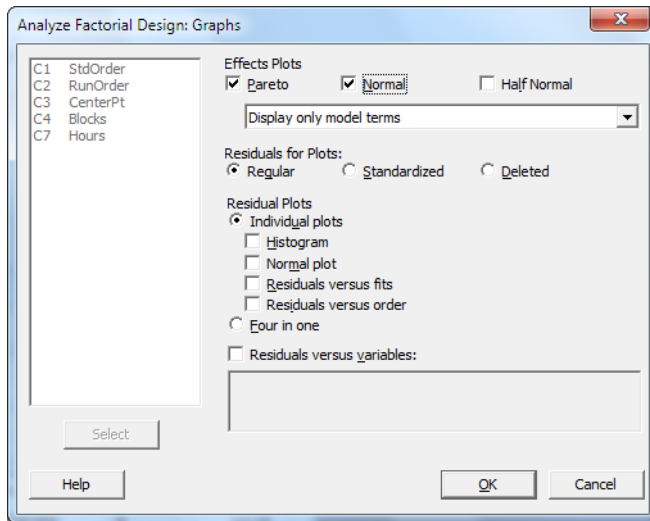
Effects plots are available only in factorial designs. Residual plots, which you use to verify model assumptions, can be displayed for all design types.

7. Click **OK** in each dialog box.
    Minitab fits the model that you defined in the **Terms** sub-dialog box, displays the results in the Session window, and stores the model in the worksheet file. After you identify an acceptable model, you can use the stored model to perform subsequent analyses.

Identify important effects

You use the Session window output and the two effects plots to determine which effects are important to your process. First, look at the Session window output.

Factorial Regression: Hours versus OrderSystem, Pack

```
Analysis of Variance

Source                DF   Adj SS   Adj MS   F-Value   P-Value
Model                  3   53.894   17.9646    40.25     0.000
  Linear               2   44.915   22.4576    50.32     0.000
    OrderSystem        1   28.768   28.7680    64.46     0.000
    Pack               1   16.147   16.1472    36.18     0.000
  2-Way Interactions   1    8.979    8.9787    20.12     0.002
    OrderSystem*Pack   1    8.979    8.9787    20.12     0.002
Error                  8    3.571    0.4463
Total                 11   57.464


Model Summary

      S     R-sq   R-sq(adj)   R-sq(pred)
0.668069   93.79%     91.46%       86.02%


Coded Coefficients

Term              Effect    Coef   SE Coef   T-Value   P-Value   VIF
Constant                  12.573     0.193     65.20     0.000
```

```
OrderSystem         3.097   1.548    0.193    8.03    0.000  1.00
Pack               -2.320  -1.160    0.193   -6.01    0.000  1.00
OrderSystem*Pack    1.730   0.865    0.193    4.49    0.002  1.00
```

```
Regression Equation in Uncoded Units

Hours = 12.573 + 1.548 OrderSystem - 1.160 Pack + 0.865 OrderSystem*Pack
```

```
Alias Structure

Factor   Name

A        OrderSystem
B        Pack


Aliases

I
A
B
AB
```

You fit the full model, which includes the two main effects and the 2-way interaction. Effects are statistically significant when their p-values in the Coded Coefficients table are less than α. At the default α of 0.05, the following effects are significant:

- The main effects for the order-processing system (OrderSystem) and the packing procedure (Pack)

- The interaction effect of the order-processing system and the packing procedure (OrderSystem*Pack)

Interpret the effects plots

You can also evaluate the normal probability plot and the Pareto chart of the standardized effects to see which effects influence the response, Hours.

1. To view the normal probability plot, choose **Window** > **Effects Plot for Hours**.
    Square symbols identify significant terms. OrderSystem (A), Pack (B), and OrderSystem*Pack (AB) are significant because their p-values are less than the α of 0.05.
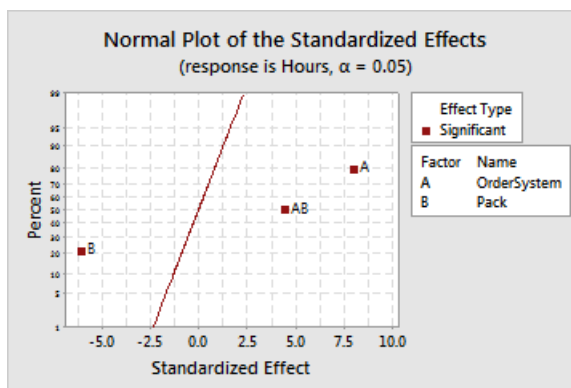
2.   To view the Pareto chart, choose **Window** > **Effects Pareto for Hours**.
        Minitab displays the absolute value of the effects on the Pareto chart. Any effects that extend beyond the
        reference line are significant. OrderSystem (A), Pack (B), and OrderSystem*Pack (AB) are all significant.
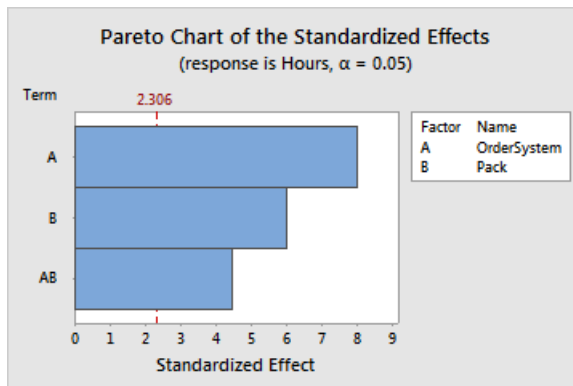
Use the stored model for additional analyses

You identified a model that includes the significant effects, and Minitab stored the model in the worksheet. A check mark in the heading of the response column indicates that a model is stored and it is up to date. Hold the pointer over the check mark to view a summary of the model.

You can use the stored model to perform additional analyses to better understand your results. Next, you create factorial plots to identify the best factor settings, and you use Minitab's **Predict** analysis to predict the number of hours for those settings.

Create factorial plots

You use the stored model to create a main effects plot and an interaction plot to visualize the effects.

1.   Choose **Stat** > **DOE** > **Factorial** > **Factorial Plots**.

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2. Verify that the variables, **OrderSystem** and **Pack**, are in the **Selected** box.
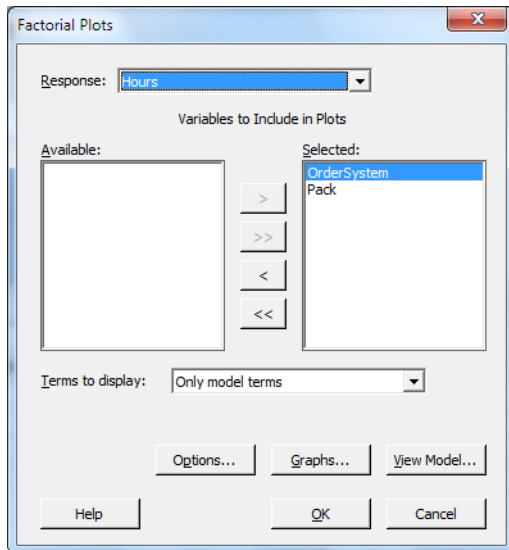
3. Click **OK**.

Interpret the factorial plots

The factorial plots include the main effects plot and the interaction plot. A main effect is the difference in the mean response between two levels of a factor. The main effects plot shows the means for Hours using both order-processing systems and the means for Hours using both packing procedures. The interaction plot shows the impact of both factors, order-processing system and packing procedure, on the response. Because an interaction means that the effect of one factor depends on the level of the other factor, assessing interactions is important.

1. To view the main effects plot, choose **Window** > **Main Effects Plot for Hours**.
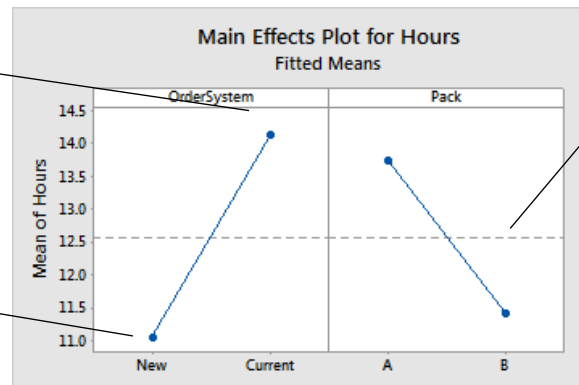
Each point represents the mean processing time for one level of a factor. The horizontal center line shows the mean processing time for all runs. The left panel of the plot indicates that orders that were processed using the new order-processing system took less time than orders that were processed using the current order-processing system. The right panel of the plot indicates that orders that were processed using packing procedure B took less time than orders that were processed using packing procedure A.

If there were no significant interactions between the factors, a main effects plot would adequately describe the relationship between each factor and the response. However, because the interaction is significant, you should also examine the interaction plot. A significant interaction between two factors can affect the interpretation of the main effects.

2.   Choose **Window** > **Interaction Plot for Hours** to make the interaction plot active.

The vertical scale (y-axis) is in units of the response (Hours).

This point is the mean time needed to prepare packages using the new order-processing system and packing procedure A.
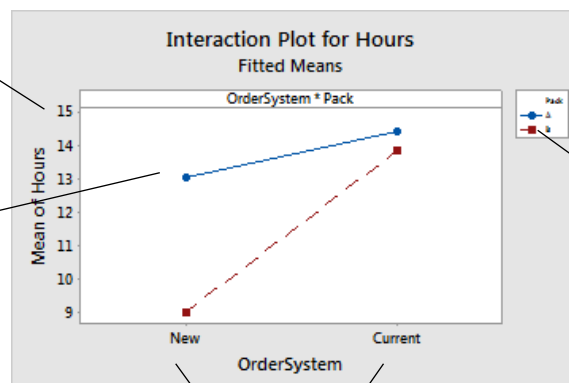
The legend displays the levels of the factor, Pack.

The horizontal scale (x-axis) shows the levels of the factor, OrderSystem.

Each point in the interaction plot shows the mean processing time at different combinations of factor levels. If the lines are not parallel, the plot indicates that there is an interaction between the two factors. The interaction plot indicates that book orders that were processed using the new order-processing system and packing procedure B took the fewest hours to prepare (9 hours). Orders that were processed using the current order-processing system and packing procedure A took the most hours to prepare (approximately 14.5 hours). Because the slope of the line for packing procedure B is steeper, you conclude that the new order-processing system has a greater effect when packing procedure B is used instead of packing procedure A.

Based on the results of the experiment, you recommend that the Western shipping center use the new order-processing system and packing procedure B to decrease the time to deliver orders.

Predict the response

You determined the best settings, which are stored in the DOE model in the worksheet. You can use the stored model to predict the processing time for these settings.

1.   Choose **Stat** > **DOE** > **Factorial** > **Predict**.
2.   Under **OrderSystem**, select **New**.

3.   Under **Pack**, select **B**.
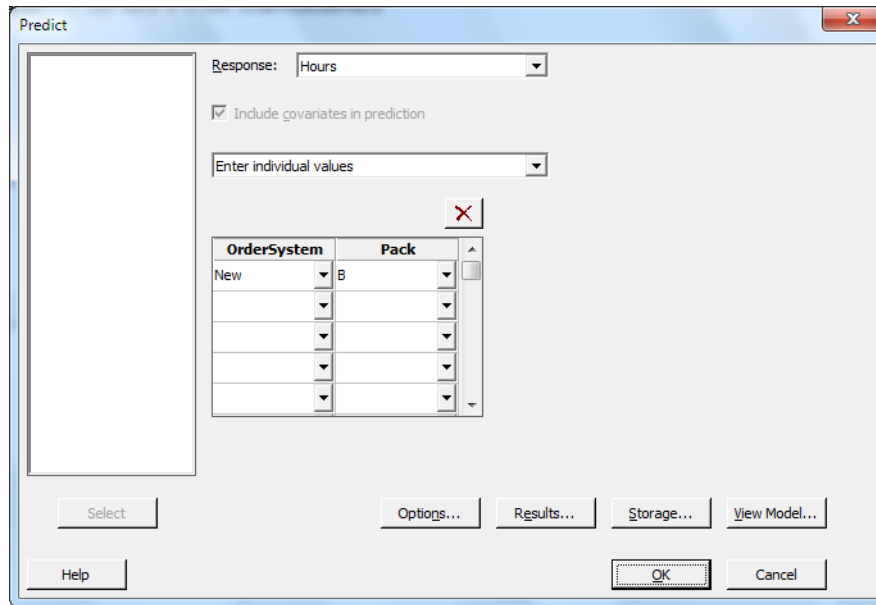
4.   Click **OK**.

Prediction for Hours

```
Regression Equation in Uncoded Units

Hours = 12.573 + 1.548 OrderSystem - 1.160 Pack + 0.865 OrderSystem*Pack

Variable       Setting
OrderSystem       New
Pack                B

Fit     SE Fit        95% CI                 95% PI
  9   0.385710  (8.11055, 9.88945)  (7.22110, 10.7789)
```

Interpret the results

The Session window output displays the model equation and the variable settings. The fitted value (also called predicted value) for these settings is 9 hours. However, all estimates contain uncertainty because they use sample data. The 95% confidence interval is the range of likely values for the mean preparation time. If you use the new order-processing system and packing procedure B, you can be 95% confident that the mean preparation time for all orders will be between 8.11 and 9.89 hours.

Save the project

1.   Choose **File** > **Save Project As**.
2.   Browse to the folder that you want to save your files in.
3.   In **File name**, enter *MyDOE*.
4.   Click **Save**.

In the next chapter

The factorial experiment indicates that you can decrease the time that is needed to prepare orders at the Western shipping center by using the new order-processing system and packing procedure B. In the next chapter, you learn how to use command language and create and run exec files to quickly re-run an analysis when new data are collected.

6 Using Session Commands

Objectives

Overview

Each menu command has a corresponding session command. Session commands consist of a main command and, usually, one or more subcommands. Main commands and subcommands can be followed by a series of arguments, which can be columns, constants, matrices, text strings, or numbers. You can use session commands to quickly re-run an analysis in current or future sessions, or as an alternative to menu commands. Minitab provides three ways to use session commands:

- Type session commands into the **Session** window or the **Command Line Editor**.
- Copy session commands from the **History** folder to the **Command Line Editor**.
- Copy and save session commands in an exec file.

When you enable session commands, and then execute a command from a menu, the corresponding session commands are displayed in the Session window along with your text output. This technique is a convenient way to learn session commands.

The Western shipping center continuously collects and analyzes delivery time when new data are available. In Assessing Quality on page 33, you conducted a capability analysis on data from March. In this chapter, you use session commands to perform a capability analysis on data from April.

Enable and enter session commands

One way to use session commands is to enter them at the command prompt in the Session window. Minitab does not display the command prompt in the Session window by default, so you must enable it.

Enable session commands

1. If you are continuing from the previous chapter, choose **File** > **New** > **Project**. If not, start Minitab.
2. Choose **Help** > **Sample Data**.
3. Double-click the Getting Started folder, then double-click SessionCommands.MTW.
4. Click the Session window to make it active.

5.   Choose **Editor** > **Enable Commands**.
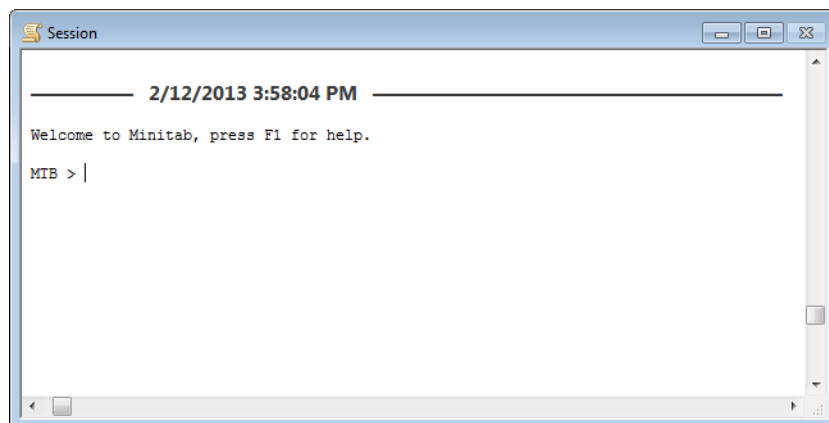
   The MTB> prompt is displayed in the Session window.

6.   (Optional) Enable session commands by default for all Minitab sessions.
  a.   Choose **Tools** > **Options**. Expand **Session Window**, then select **Submitting Commands**.
  b.   Under **Command Language**, click **Enable**.

Perform an analysis using session commands

In Assessing Quality on page 33, you performed a capability analysis to determine whether delivery times were within specifications (less than 6 delivery days). To perform this analysis, you used **Stat** > **Quality Tools** > **Capability Analysis** > **Normal**. Then, you entered the data column, the subgroup column, and the upper specification limit.

To continue assessing the delivery times at the Western shipping center, you plan to repeat this analysis at regular intervals. When you collect new data, you can repeat this analysis using a few session commands.

1.   In the Session window, at the MTB > prompt, enter `CAPABILITY 'Days' 'Date';`

      The semicolon indicates that you want to enter a subcommand.

2.   Press **Enter**.

      Notice that MTB > becomes SUBC>. Use the SUBC> prompt to add subcommands for the options from the earlier capability analysis.
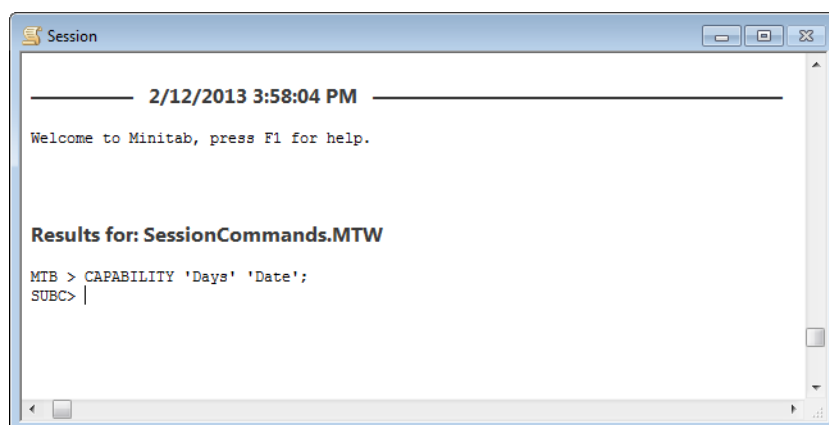
3.   At the SUBC> prompt, enter `USPEC 6.`

      The period indicates the end of a command sequence.

4.   Press **Enter**.

Capability analysis for the April shipping data
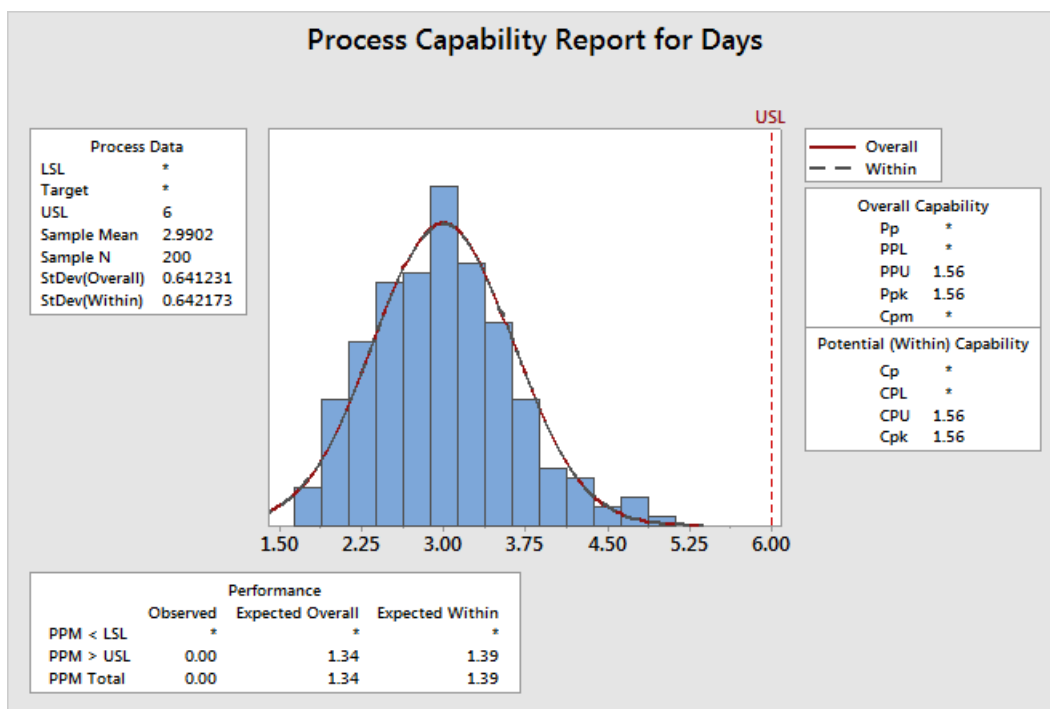
Tip   For more information about specific session commands, at the command prompt, enter `Help` and the first four letters of the command name.

Re-execute a series of commands

Minitab generates session commands for most menu commands and stores them in the **History** folder. You can re-execute these commands by selecting them and choosing **Edit** > **Command Line Editor**.

Use the **History** folder and the **Command Line Editor** to re-run the capability analysis.

1. Choose **Window** > **Project Manager**.
2. Click the **History** folder.
3. Click `CAPABILITY 'Days' 'Date';`, press and hold **Shift**, and then click `USPEC 6.`
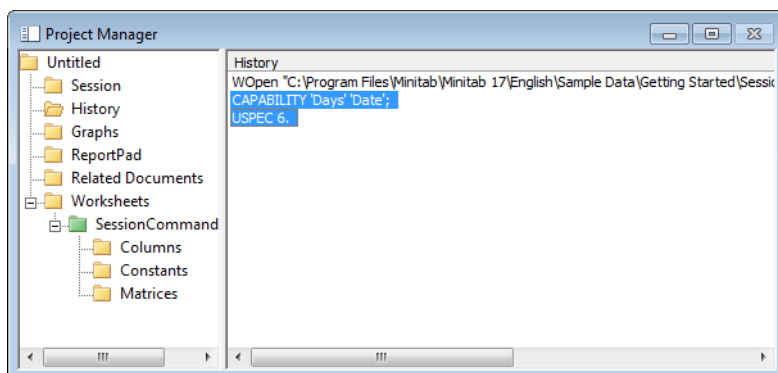
4.   Choose **Edit** > **Command Line Editor**.
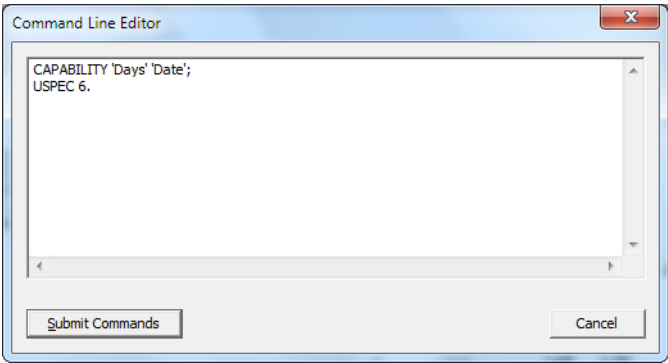
5.   Click **Submit Commands**.

Capability analysis for the April shipping data
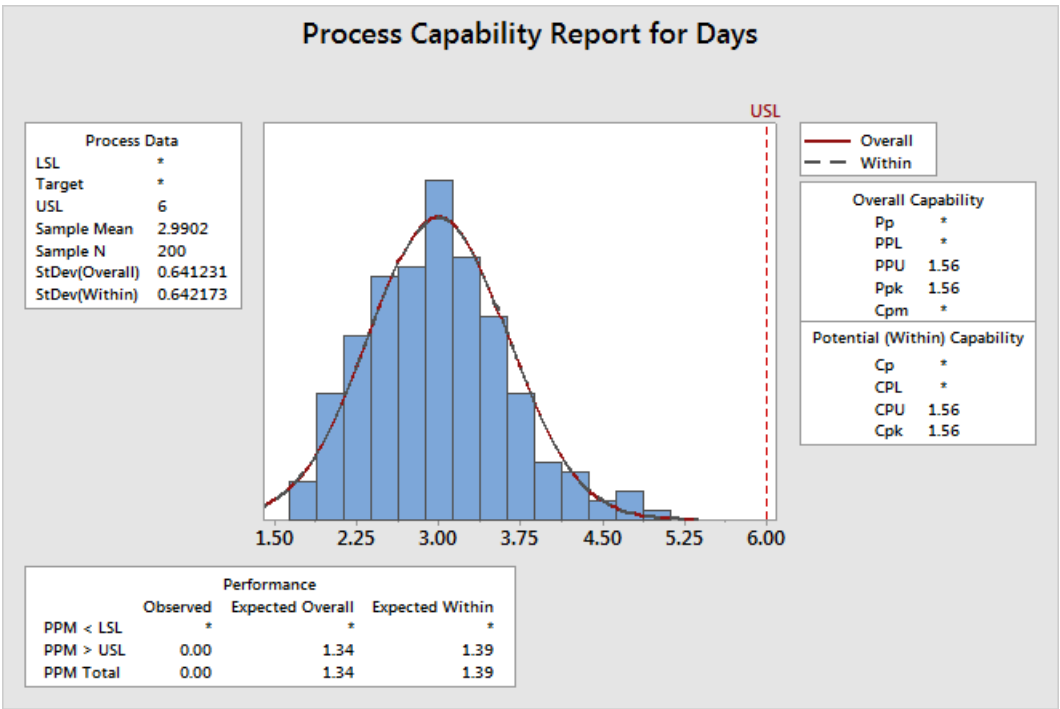
You have re-created the capability analysis in a few simple steps.

Repeat analyses with exec files

An exec file is a text file that contains a series of Minitab commands. To repeat an analysis without using menu commands or session commands, save the commands as an exec file and then run the exec file.

Tip   For more information about exec files and other more complex macros, choose **Help** > **Help**. Under **References**, click **Macros**.

Create an exec file from the History folder

Save the session commands for the capability analysis as an exec file.

1. Choose **Window** > **Project Manager**.
2. Click the **History** folder.
3. Click `CAPABILITY 'Days' 'Date';`, press **Shift**, then click `USPEC 6.`
4. Right-click the selected text, then choose **Save As**.
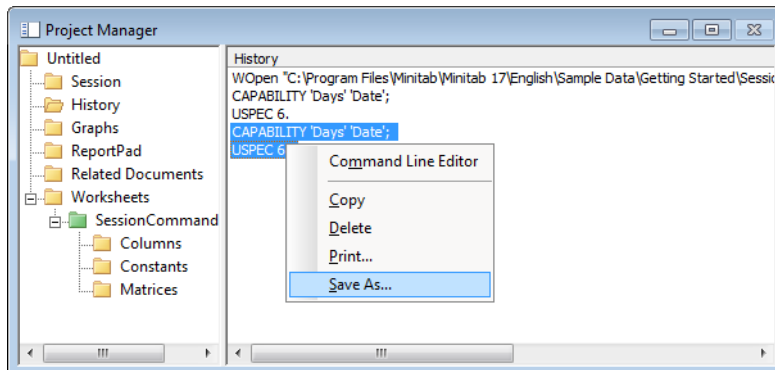
5. Browse to the folder that you want to save your files in.
6. In **File name**, enter *ShippingGraphs*.
7. From **Save as type**, select **Exec (*.MTB)**. Click **Save**.

Re-execute commands

You can repeat this analysis by running the exec file.

1. Choose **Tools** > **Run an Exec**.
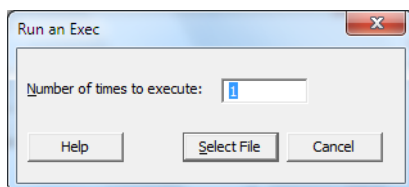
2. Click **Select File**.
3. Select the file, ShippingGraphs.MTB, then click **Open**.

   Capability analysis for the April shipping data
   Minitab executes the commands in the exec file to generate the capability analysis.

Process Capability Report for Days

Process Data	
LSL	*
Target	*
USL	6
Sample Mean	2.97781
Sample N	210
StDev(Overall)	0.638268
StDev(Within)	0.638177

— Overall
− − Within

Overall Capability	
Pp	*
PPL	*
PPU	1.58
Ppk	1.58
Cpm	*

Potential (Within) Capability	
Cp	*
CPL	*
CPU	1.58
Cpk	1.58

Performance

	Observed	Expected Overall	Expected Within
PPM < LSL	*	*	*
PPM > USL	0.00	1.10	1.09
PPM Total	0.00	1.10	1.09
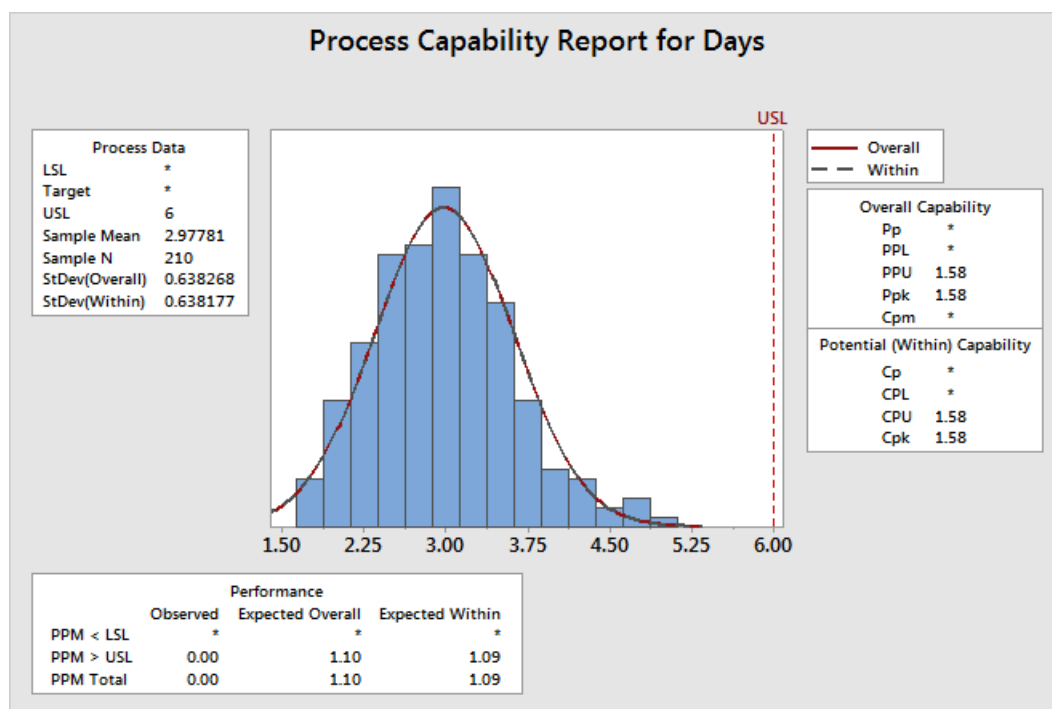
You can run an exec file using any worksheet if the column names match. Therefore, you can share an exec file with other Minitab users who need to perform the same analysis. For example, the manager of the Western shipping center can share ShippingGraphs.MTB with the managers of the other shipping centers so that they can perform the same analysis on their own data. If you want to use an exec file with a different worksheet or with different columns, edit the exec file using a text editor such as Notepad.

Save the project

Save all your work in a Minitab project.

1. Choose **File** > **Save Project As**.
2. Browse to the folder that you want to save your files in.
3. In **File name**, enter *MySessionCommands*.
4. Click **Save**.

In the next chapter

You learned how to use session commands as an alternative to menu commands and as a way to quickly repeat an analysis. In the next chapter, you create a report to show the results of your analysis to your colleagues.

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7 Generating a Report

Objectives

Overview

You can create reports that include your Minitab results in the following ways:

- Add results to the ReportPad.
- Use **Copy to Word Processor** to copy content from the ReportPad to a word processor.
- Send Session window output and graphs directly to Microsoft Word or PowerPoint.

To show your colleagues the results of the shipping data analysis, you want to prepare a report that includes results from your Minitab sessions.

Use the ReportPad

You performed several analyses, and you want to share the results with colleagues. Minitab's Project Manager contains a folder, called the **ReportPad**, in which you can create simple reports.

In ReportPad, you can do the following:

- Store results in a single document
- Rearrange your results
- Add comments and headings
- Change font sizes
- Save results as an .rtf file or an .html file
- Print the entire output from an analysis

Add a graph to the ReportPad

You can add results to ReportPad by right-clicking on a graph or Session window output and then choosing **Append Section to Report**. You can also copy and paste text and graphs from other applications into ReportPad.

Add the paneled histogram, which you created in Graphing Data on page 10, to the ReportPad.

1. Choose **File** > **Open**.

2.   Browse to C:\Program Files (x86)\Minitab\Minitab 17\English\Sample Data\Getting Started. (Adjust this filepath if you chose to install Minitab to a location other than the default.)

3.   Double-click Reports.MPJ.

4.   Choose **Window** > **Histogram of Days**.

5.   Right-click the graph, then choose **Append Graph to Report**.
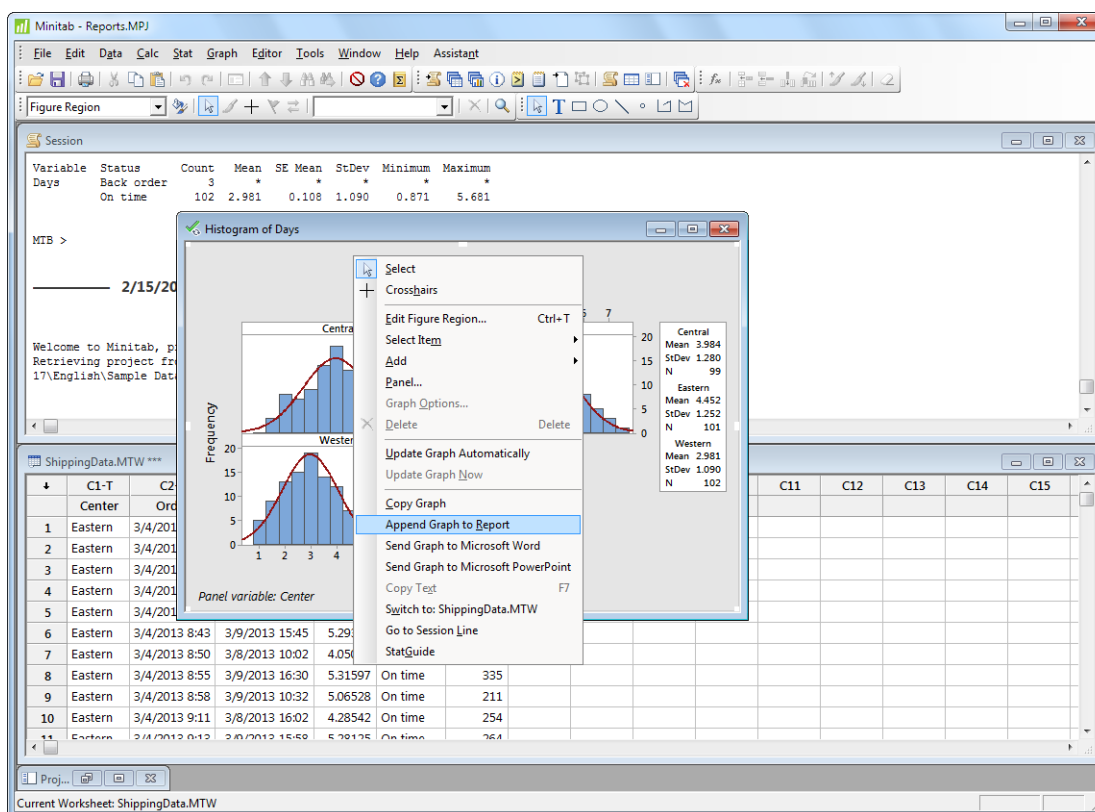
6.   Choose **Window** > **Project Manager**.

7.   Click the **ReportPad** folder. The histogram is added to the ReportPad.

Add Session window output to the ReportPad

In Analyzing Data on page 22, you displayed descriptive statistics for the three regional shipping centers. Add the Session window output for the three shipping centers to the ReportPad.

1.   Choose **Window** > **Session**.

2. In the Session window, click in the output for Results for Center = Central, right-click, then choose **Append Section to Report**. Sections of Session window output are separated by titles, which are in bold text.
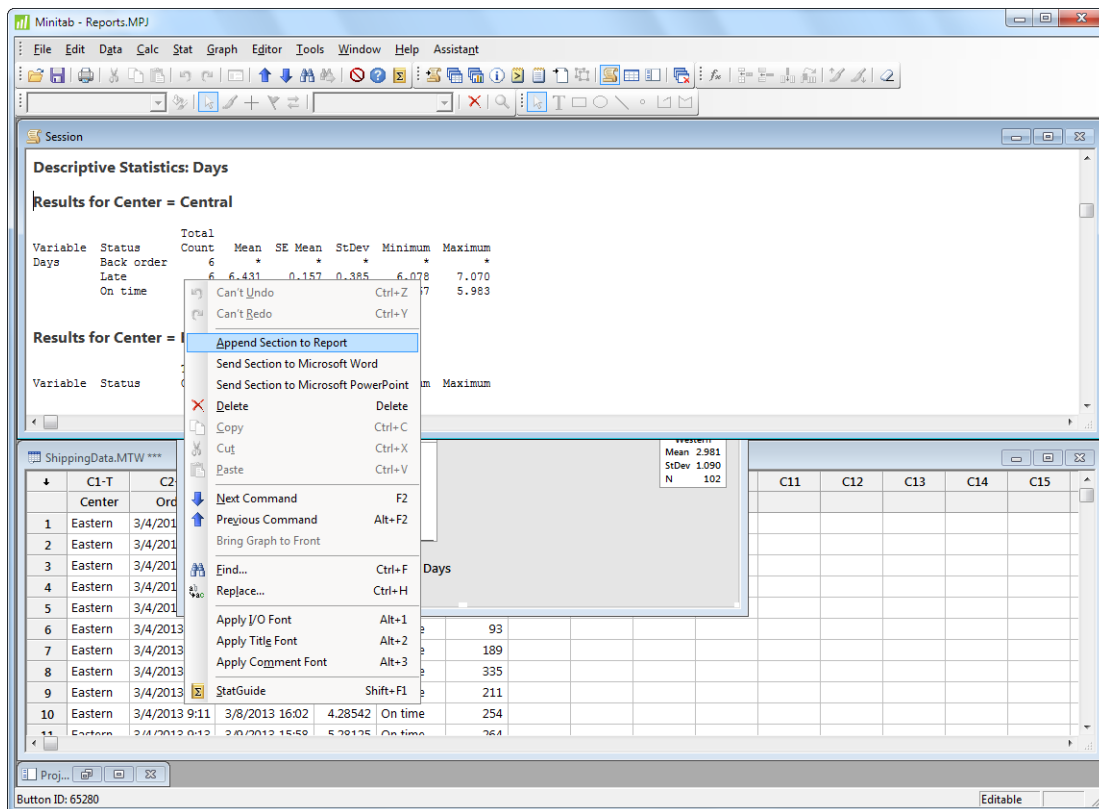
3. Repeat the steps above for Results for Center = Eastern and Results for Center = Western.

4. Choose **Window** > **Project Manager**, then click the **ReportPad** folder. Maximize the window to see more of your report.
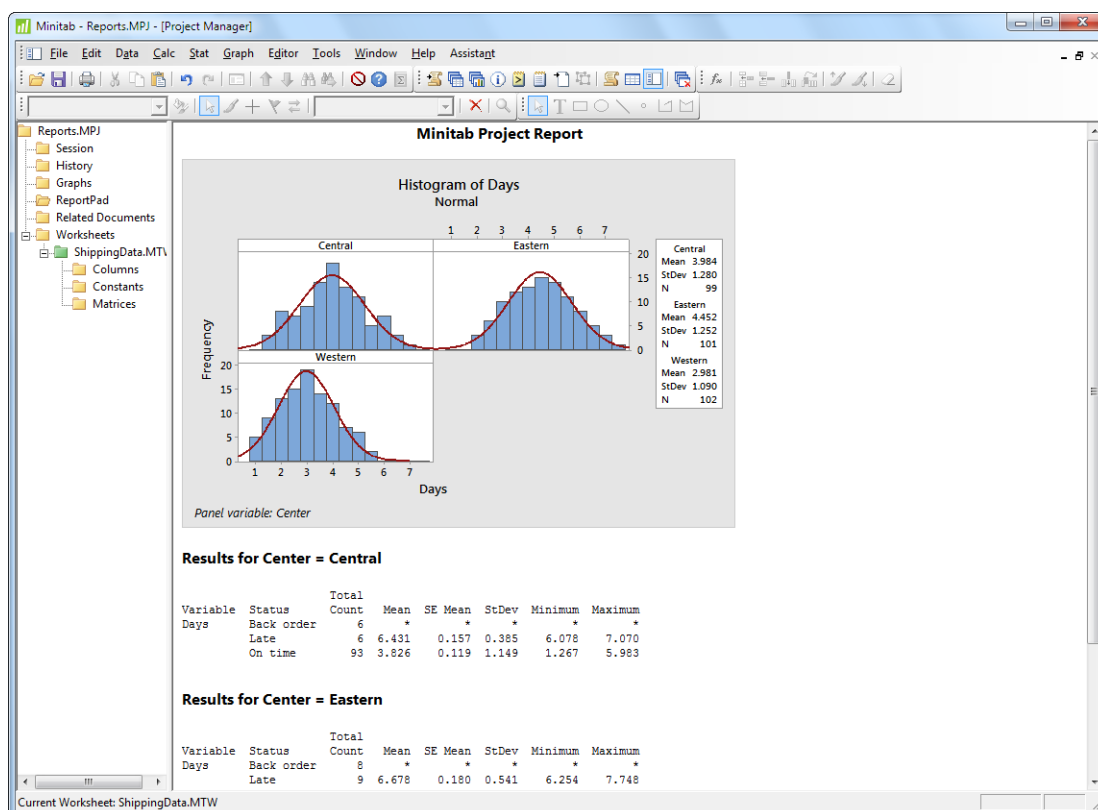
Note   To add multiple sections of Session window output to the ReportPad at the same time, do the following:

1.   Select the Session window output that you want to add.

2.   Right-click in the Session window, then choose **Append Selected Lines to Report**.

Edit the report

Customize the report by replacing the default title and adding a short comment to the graphical output.

1.   Select the title, **Minitab Project Report**. Enter *Report on Shipping Data*. Press **Enter**.
2.   Below **Report on Shipping Data**, enter *Histogram of delivery time by center*.
3.   Select the text, **Histogram of delivery time by center**, right-click the text, then choose **Font**.
4.   From **Color**, select **Maroon**.
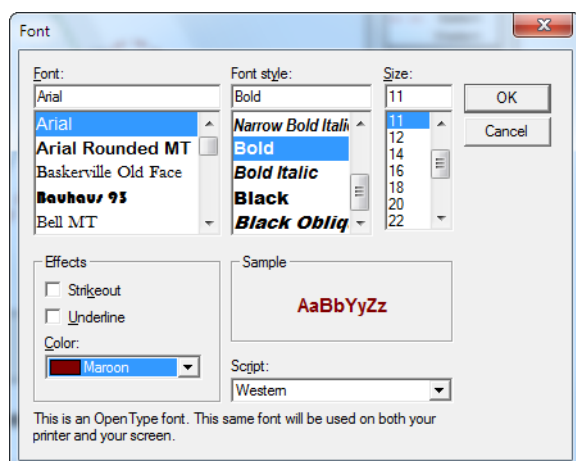
5.   Click **OK**.
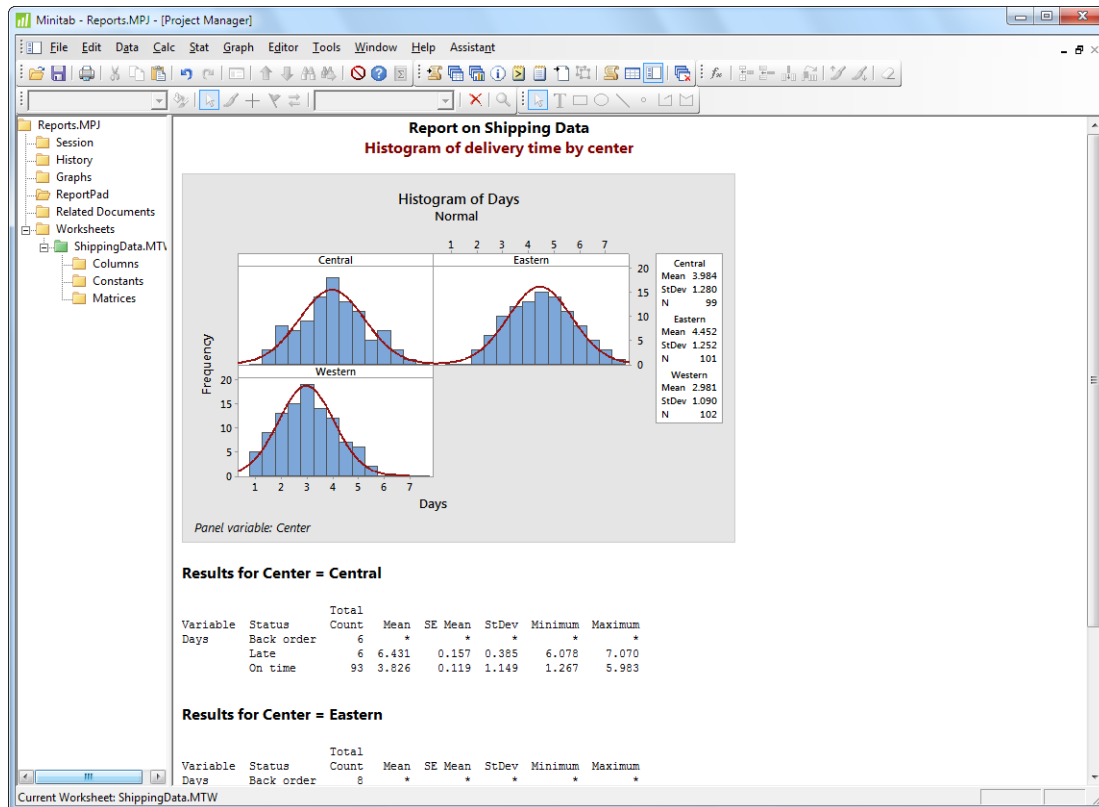
You now have a simple report that illustrates some of your results. Minitab saves the ReportPad contents as part of the project.

Save the report

You can save the contents of the ReportPad, as well as Session window output and worksheets, either as an .rtf file or an .html file.

Save your report as an .rtf file.

1. In the Project Manager, right-click the **ReportPad** folder, then choose **Save Report As**.
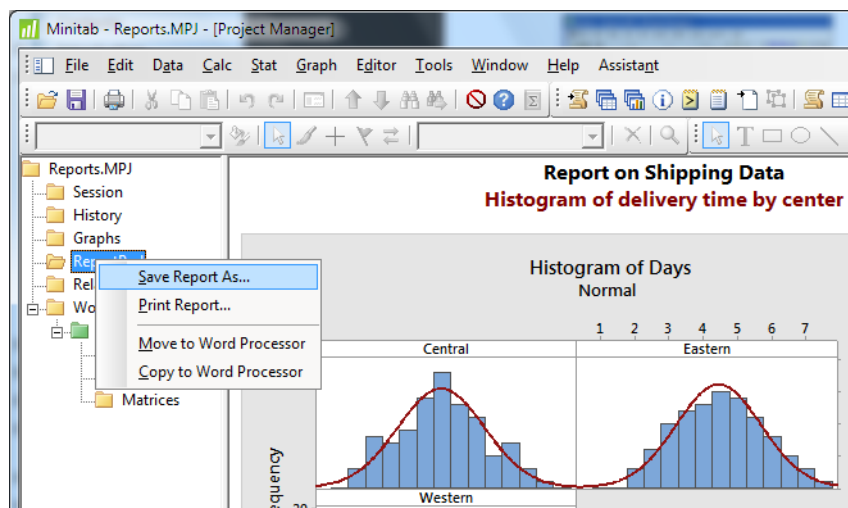
2. Browse to the folder that you want to save your files in.
3. In **File name**, enter *ShippingReport1*.
4. From **Save as type**, select **Rich Text Format (*.RTF)**. Click **Save**.

Copy the report to a word processor

Word processors provide more extensive format and layout options than ReportPad. The following tools in ReportPad let you transfer the contents of the ReportPad to your word processor without copying and pasting:

Move to Word Processor
  Transfers the ReportPad contents to a word processor and deletes the contents of the ReportPad.

Copy to Word Processor
  Copies the ReportPad contents into a word processor while leaving the original contents in the ReportPad.

1. In the Project Manager, right-click the **ReportPad** folder, then choose **Copy to Word Processor**.
2. In **File name**, enter *ShippingReport2*.

    You do not need to choose a file type because .rtf is the only option available.

3. Click **Save**.
    Minitab saves the report and opens it in your default word processor.

Send output to Microsoft PowerPoint

You can also create reports or presentations by sending graphs and Session window output directly to Microsoft Word or Microsoft PowerPoint.

Add the histogram and descriptive statistics results to Microsoft PowerPoint.

1. Choose **Window** > **Histogram of Days**.

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2. Right-click the graph, then choose **Send Graph to Microsoft PowerPoint**.
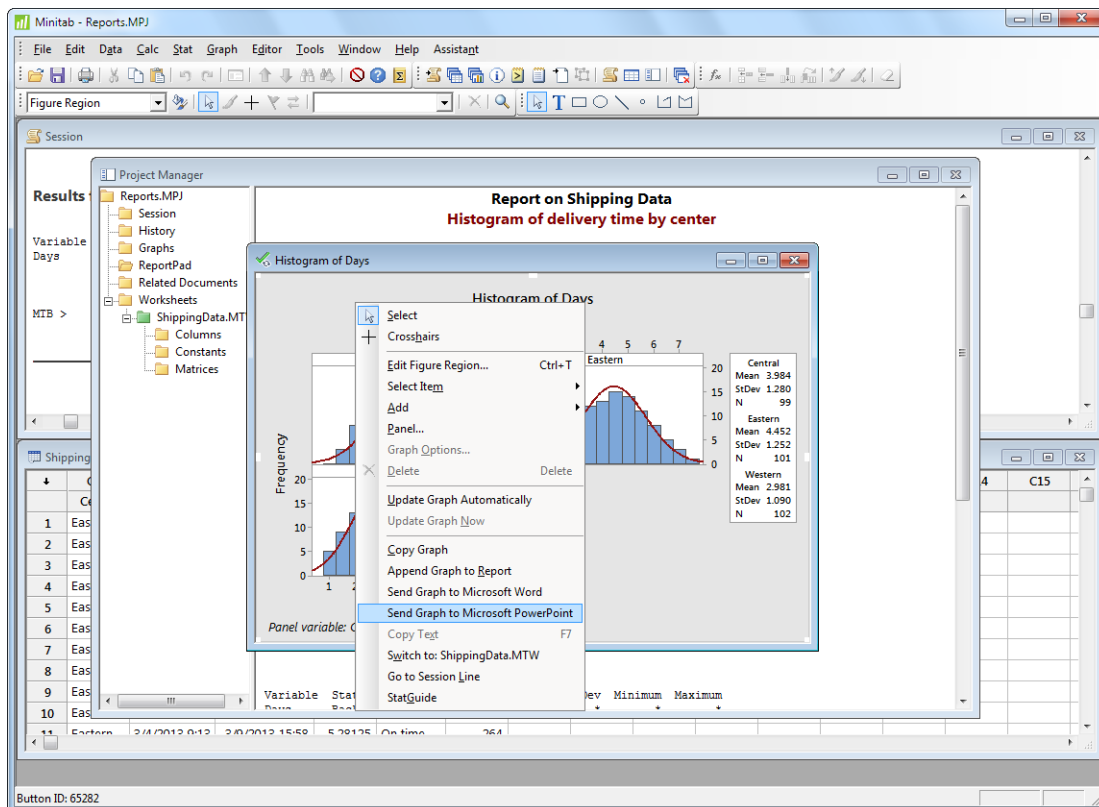
A new Microsoft PowerPoint file opens with the histogram on the first slide.

3. In Minitab, choose **Window** > **Session**.

4. In the Session window, click in the output for Results for Center = Central. Right-click, then choose **Send Section to Microsoft PowerPoint**.

5. Repeat step 4 for Results for Center = Eastern and Results for Center = Western.
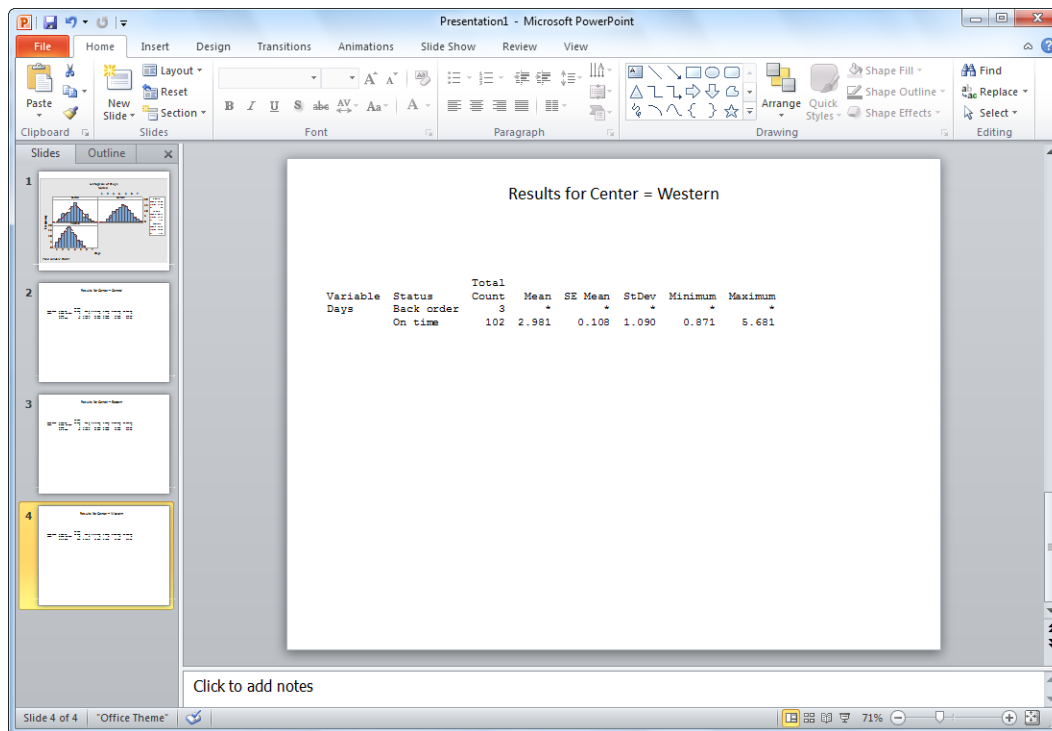
The Microsoft PowerPoint presentation contains the histogram and each part of the Session window output on separate slides.

Note   To add multiple sections of Session window output to Microsoft Word or Microsoft PowerPoint:
1. Select the Session window output.

2. Right-click in the Session window, then choose either **Send Selected Lines to Microsoft Word** or **Send Selected Lines to Microsoft PowerPoint**.

In the next chapter

In the next chapter, you learn to prepare a Minitab worksheet. You enter data in a worksheet from multiple sources. Also, to prepare the data and simplify the analysis, you edit the data and reorganize columns and rows.

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8 Preparing a Worksheet

Objectives

- Open a worksheet on page 70
- Open an Excel file on page 70
- Open a text file on page 70
- Combine the data into one worksheet on page 71
- Move and rename a column on page 72
- Recode the data on page 72
- Insert and name a new data column on page 73
- Assign a formula to a column on page 73

Overview

Frequently, you use worksheets that are already created for you. However, sometimes you must enter or import data into a Minitab worksheet before you start an analysis.

You can enter data in a Minitab worksheet in the following ways:

- Type the data directly into the worksheet.
- Copy and paste the data from other applications.
- Import the data from Microsoft Excel files or text files.

After your data are in Minitab, you might need to edit cells or reorganize columns and rows to prepare the data for analysis. Some common manipulations are stacking, subsetting, specifying column names, and editing data values.

In this chapter, you import data into Minitab from different sources. You also learn how ShippingData.MTW was prepared for analysis.

Get data from different sources

For the initial analyses in *Getting Started with Minitab 17*, the worksheet ShippingData.MTW, which contains data from three shipping centers, is already set up. However, the three shipping centers originally stored the shipping data in the following ways:

- The Eastern shipping center stored data in a Minitab worksheet.
- The Central shipping center stored data in a Microsoft Excel file.
- The Western shipping center stored data in a text file.

To analyze all the shipping data, open each file in Minitab, then stack the files into one worksheet.

Open a worksheet

Start with the data from the Eastern shipping center.

1. If you are continuing from the previous chapter, choose **File** > **New** > **Project**. If not, start Minitab.
2. Choose **Help** > **Sample Data**.
3. Double-click the Getting Started folder, then double-click Eastern.MTW.

Open an Excel file

The Central shipping center data are in an Excel spreadsheet. You can open Excel files in Minitab.

1. Choose **File** > **Open**.
2. Double-click Central.xlsx.
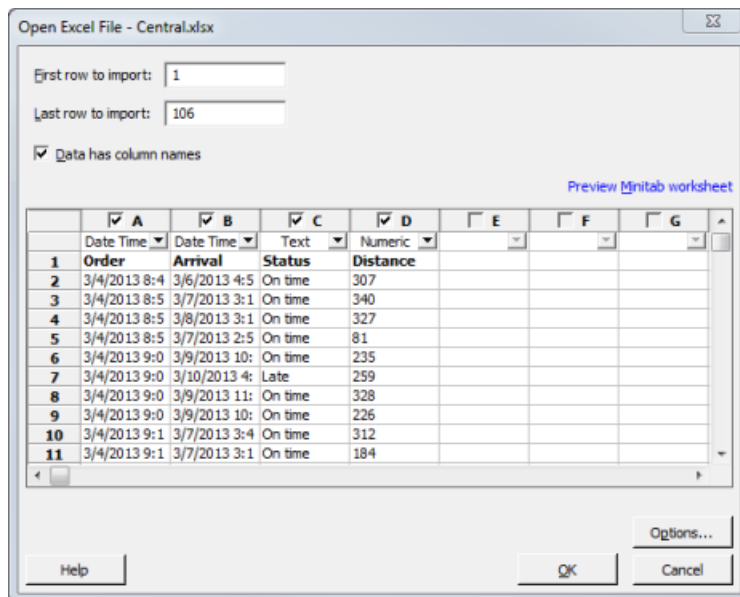
3. Click **OK**.

Open a text file

The Western shipping center data was in a text file. You can open text files in Minitab.

1. Choose **File** > **Open**.

2.   Double-click Western.txt.
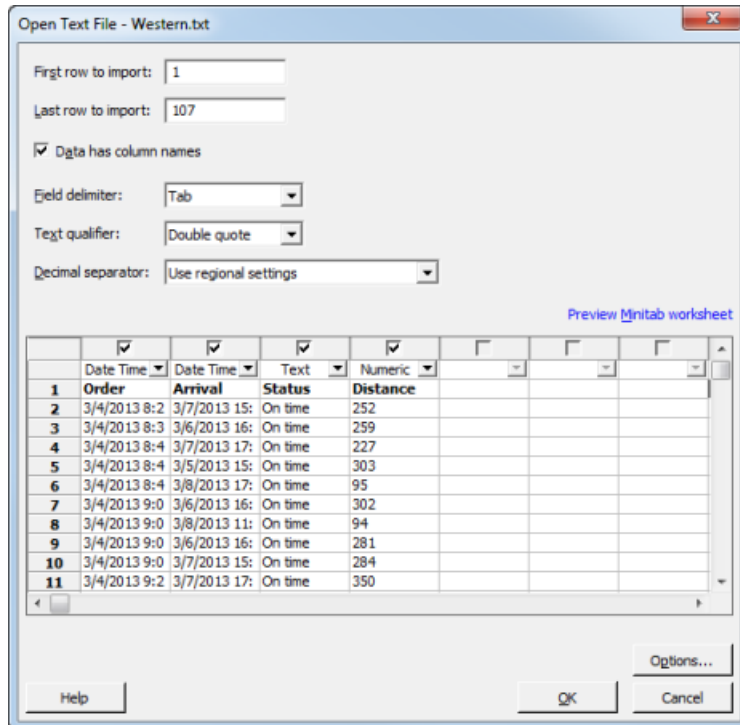
3.   Click **OK**.

Combine the data into one worksheet

Notice that the worksheets for the shipping centers have the same column names. To make the data easier to analyze, you need to combine the data into one worksheet by stacking columns that have the same names. You can move data by copying and pasting or by using commands on the **Data** menu.

1.   Choose **Data** > **Stack Worksheets**.
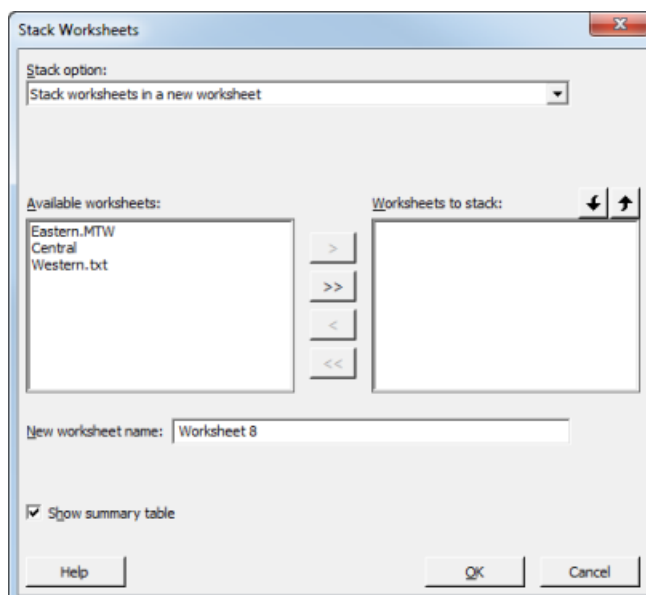
2.   From **Stack option**, select **Stack worksheets in a new worksheet**.
3.   Use the arrow buttons to move the three worksheets from **Available worksheets** to **Worksheets to stack**.

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4. In **New worksheet name**, enter MyShippingData.
5. Click **OK**.

Move and rename a column

The Source column contains the labels that identify data from the shipping centers. Move the Source column to C1, and rename the column Center.

1. Click in the Source column, then choose **Editor** > **Move Columns**.
2. Under **Move Selected Columns**, select **Before column C1**.
3. Click **OK**.
4. Click in the column name cell Source, type *Center*, and press **Enter**.

Prepare the worksheet for analysis

The data are now in a single worksheet, but you still need to manipulate the data in the following ways:

- Recode data

- Add a new column

- Create a column of calculated values

Tip   For a complete list of the data manipulations that are available in Minitab, go to **Data menu** in the Minitab Help index. To access the Minitab Help index, open Minitab, choose **Help** > **Help**, then click the **Index** tab in the left pane.

Recode the data

Some of the labels in the Center column include a file extension. Recode the labels to remove the file extension.

1. Choose **Data** > **Recode** > **To Text**.
2. In **Recode values in the following columns**, enter *Center*.
3. From **Method**, select **Recode individual values**.
4. Under **Recoded value**, replace Eastern.MTW with *Eastern*.
5. Under **Recoded value**, replace Western.txt with *Western*.

6. From **Storage location for the recoded columns**, select **In the original columns**.
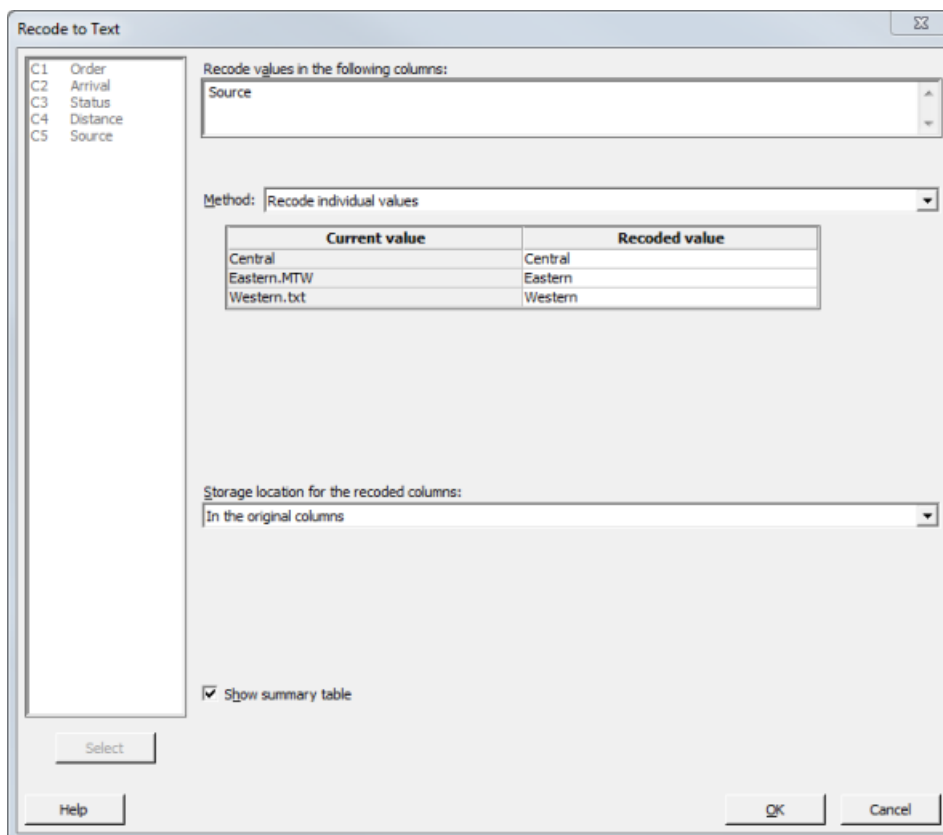
7. Click **OK**.

The labels in the Source column are now Eastern, Central, and Western.

Calculate difference values

Before you save your new worksheet and perform analyses, you need to calculate the number of days that elapsed between order dates and delivery dates. You can use Minitab's Calculator to assign a formula to a column to calculate these values. If you change or add data, the calculated values are automatically updated.

Insert a column

Insert a column between Arrival and Status.

1. Click any cell in C4 to make that column active.
2. Right-click, then choose **Insert Columns**.
3. Click in the name cell of C4. Type *Days*, then press **Enter**.

Assign a formula to a column

Use Minitab's Calculator to perform basic arithmetic or mathematical functions. Minitab stores the results in a column or a constant. You can assign a formula to a column so that the calculated values update automatically if the data change.

Calculate the delivery time and store the values in the Days column.

1. Choose **Calc** > **Calculator**.
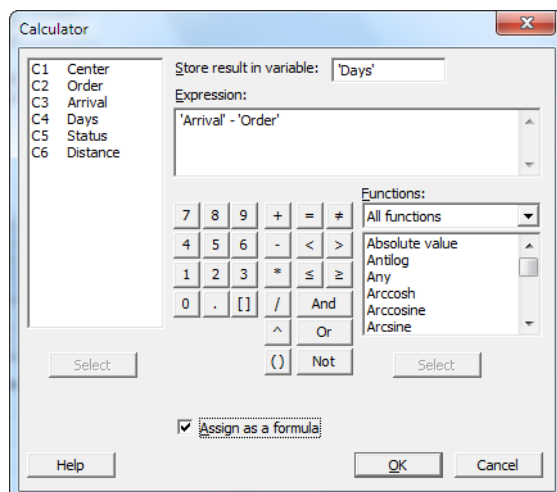
2. In **Store result in variable**, enter *Days*.
3. In **Expression**, enter *Arrival - Order*.
4. Select **Assign as a formula**.
5. Click **OK**.

Note   You can also add a formula to a column by selecting the column and choosing **Editor** > **Formulas** > **Assign Formula to Column**.

Tip   For more information on formulas in columns, go to **Formulas** in the Minitab Help index. For more information on Minitab's Calculator and the available operations and functions, go to **Calculator** in the Minitab Help index. To access the Minitab Help index, open Minitab, choose **Help** > **Help**, then click the **Index** tab in the left pane.

Examine the worksheet

The Days column contains the calculated values that represent delivery time. These values are expressed in number of days. When you assign a formula to a column, a status indicator appears in the upper right corner of the column heading on the worksheet. This indicator specifies whether the formula is properly defined and whether the data need to be updated by re-calculating the values. A green check mark ☑ indicates the data are up-to-date.

Tip   Hold the pointer over the status indicator to view the formula assigned to the column. Double-click the status indicator to edit the formula.

Update the worksheet
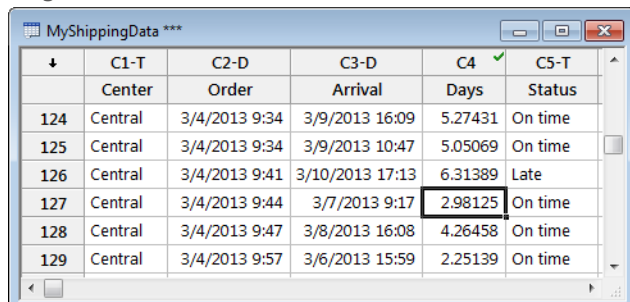
Suppose you learn that the arrival date for a shipment in the Central shipping region is incorrect. If you correct the date in the worksheet, Minitab automatically updates the Days column.

Update the arrival date in row 127.

1. In the Arrival column, double-click row 127 to put it into edit mode. Change 3/7/2013 to 3/8/2013.
2. Press **Enter**.
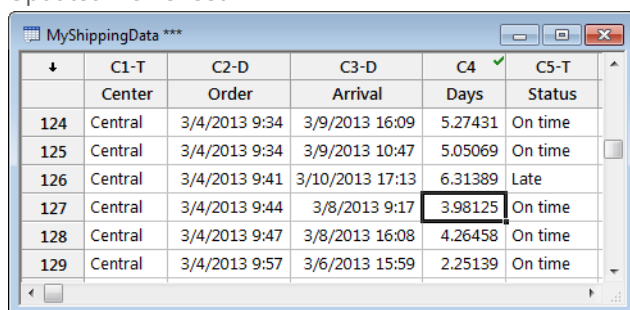
Minitab automatically updates the value in the Days column from 2.98125 to 3.98125.

Original worksheet

Updated worksheet

Note   If you prefer to update formulas manually, then choose **Editor** > **Formulas** > **Calculate All Formulas Automatically** to deselect this option. If values in the worksheet change and cause the formula in a column to be out of date, the status indicator for that column changes to a yellow triangle. Choose **Editor** > **Formulas** > **Calculate All Formulas Now** to update all formulas in the project.

Save the worksheet

Save all your work in a Minitab worksheet.

1. Click in the worksheet, then choose **File** > **Save Worksheet As**.
2. Browse to the folder that you want to save your files in.
3. In **File name**, enter *MyShippingData*.
4. From **Save as type**, select **Minitab**.
5. Click **Save**.

In the next chapter

The shipping center data from several sources are in Minitab and are set up properly for analysis. In the next chapter, you adjust Minitab default settings to make future analyses easier.

9 Customizing Minitab

Objectives

Overview

Minitab has several tools for changing default options or creating custom toolbars and keyboard shortcuts.

Use **Tools** > **Options** to change the default options for many Minitab features such as the following:

- Program settings (such as memory usage, initial directory, window layout, and dialog boxes)
- Worksheets and the Session window
- Statistical commands
- Graphs

Use **Tools** > **Customize** to do the following:

- Assign a shortcut key to a menu item.
- Set options for how Minitab displays toolbars.
- Create custom icons for menu items or toolbar buttons.

You finished your first analysis and generated a report. You now decide to use **Tools** > **Options** and **Tools** > **Customize** to customize the Minitab interface to make future analyses quicker and easier.

Set options

You can change many options during a Minitab session, such as changing graph display options or enabling the session command prompt. However, when you close Minitab, these options revert to the default settings.

If you want an option to be a default option for all Minitab sessions, use **Tools** > **Options**. Options that you change remain active until you change them again.

Note   You can restore Minitab's default options at any time. For more information, see the section "Restore Minitab's default options" below.

Add an automatic footnote

Because you will create the same graphs with similar data in the future, you need a way to distinguish the results of each analysis. You decide to add an automatic footnote to your graphs to include the worksheet name and the modification date.

1. If you are continuing from the previous chapter, choose **File** > **New** > **Project**. If not, start Minitab.
2. Choose **Help** > **Sample Data**.
3. Double-click the Getting Started folder, then double-click ShippingData.MTW.
4. Choose **Tools** > **Options**. Expand **Graphics**, expand **Annotation**, then select **My Footnote**.
5. Under **Information to include in my footnote**, select **Worksheet name** and **Date the graph was last modified**.
6. In **Custom text**, enter *Shipping center efficiency*.
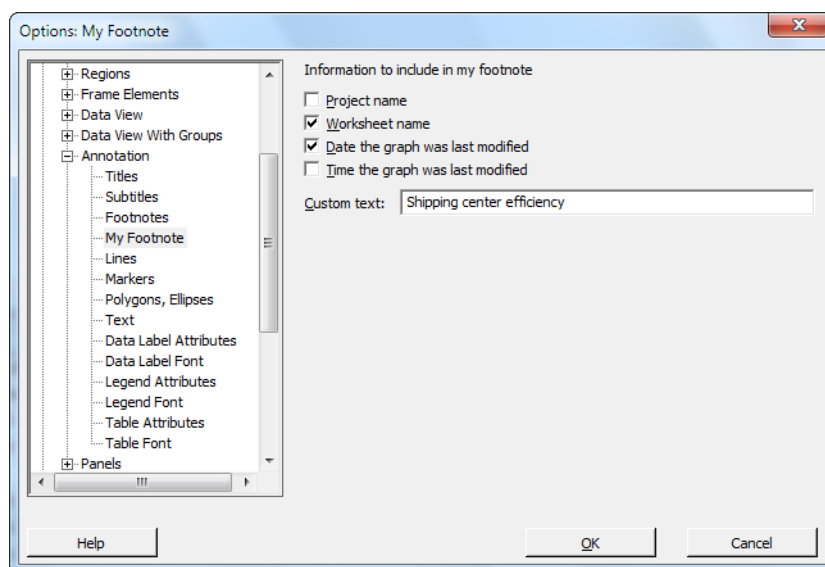
7. Click **OK**.

With these options, each time you create a graph, Minitab adds the footnote.

Create a histogram to view the footnote

To see an example of the automatic footnote, create a histogram.

1. Choose **Graph** > **Histogram**.
2. Click **With Fit**, then click **OK**.
3. In **Graph variables**, enter *Days*.
4. Click **Multiple Graphs**.
5. On the **By Variables** tab, in **By variables with groups in separate panels**, enter *Center*.
6. Click **OK** in each dialog box.

Panel variable: Center
Worksheet: ShippingData.MTW; 3/22/2013; Shipping center efficiency
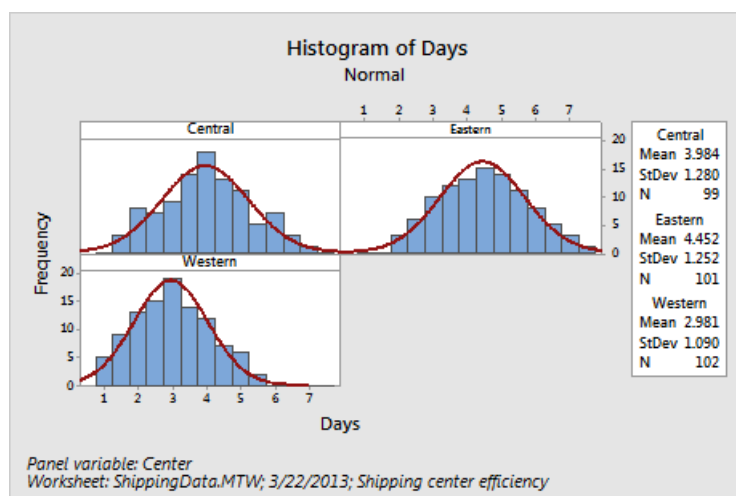
Create a custom toolbar

Use **Tools** > **Customize** to create new menus and toolbars that contain the commands that you use frequently.
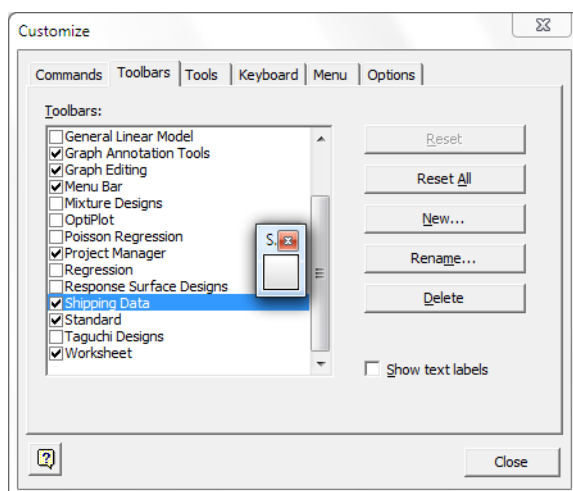
Create a toolbar

During some analyses, you return to the same menu items many times. You can simplify future analyses if you add these items to a custom toolbar.

Create a custom toolbar that includes some of the commands that you used in the shipping data analysis.

1. Choose **Tools** > **Customize**.
2. On the **Toolbars** tab, click **New**.
3. In **Toolbar Name**, enter *Shipping Data*.
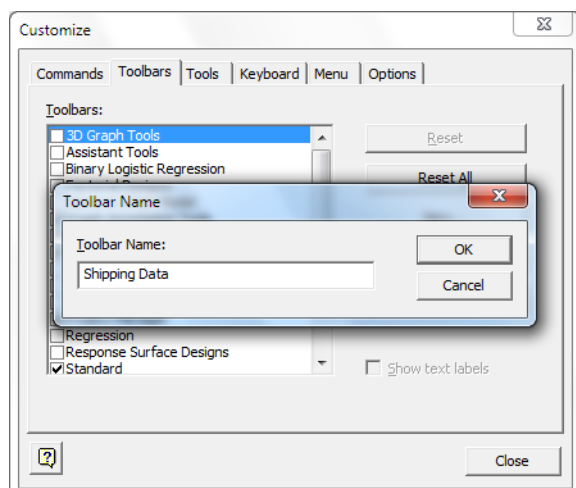
4. Click **OK**.

Minitab creates the blank toolbar, and the new toolbar is displayed in the toolbar list.

Add commands to the toolbar

In the shipping data analysis, you used **Graph** > **Histogram** and **Assistant** > **Graphical Analysis** > **Scatterplot (Groups)**. Add these commands to the blank toolbar.

1. Drag the blank toolbar to dock it beside an existing Minitab toolbar.
2. On the **Commands** tab, under **Categories**, select **Graph**.
3. Under **Commands**, select **Histogram**.
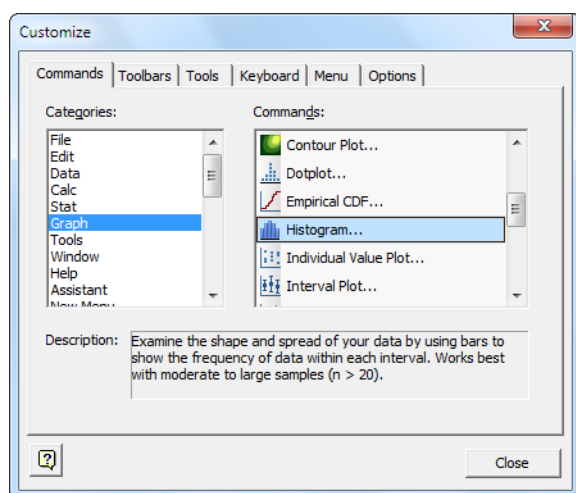
4. Drag **Histogram** to the new toolbar.
5. Under **Categories**, select **Assistant**.
6. Under **Commands**, select **Scatterplot (Groups)**.
7. Drag **Scatterplot (Groups)** to the new toolbar.

Histogram   Scatterplot
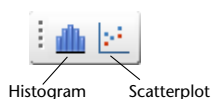
8. Click **Close**.

> **Tip**   You can also create a custom menu. For more information about **Tools** > **Customize**, go to **Customize** in the Minitab Help index. To access the Minitab Help index, open Minitab, choose **Help** > **Help**, then click the **Index** tab in the left pane.

Assign a shortcut key

Minitab contains many shortcut keys for frequently used functions. You can also assign shortcut keys for the commands that you use often. To assign shortcut keys, use **Tools** > **Customize** > **Keyboard**.

Because you often create histograms for your shipping data analysis, you want to assign a shortcut key for this command.

1. Choose **Tools** > **Customize**.
2. On the **Keyboard** tab, from **Category**, select **Graph**.
3. Under **Commands**, select **Histogram**.
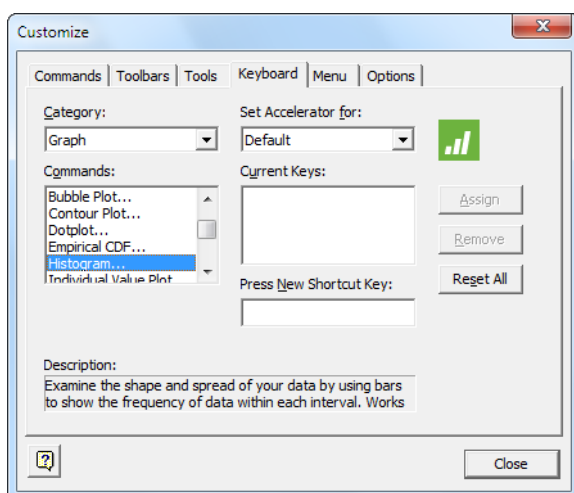
4. Click in **Press New Shortcut Key**.
5. Press **Ctrl+Shift+H**.
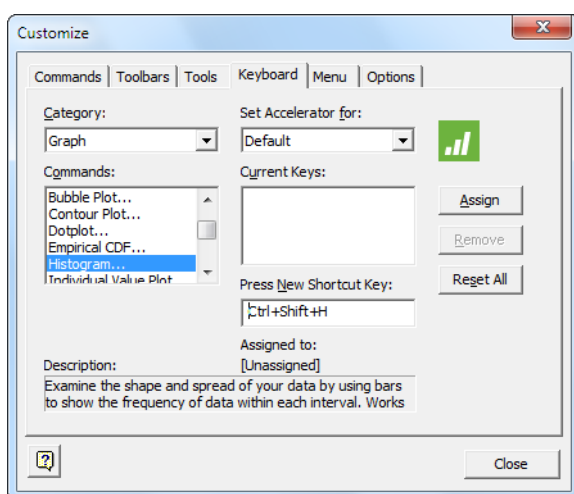
Under **Press New Shortcut Key**, the **Assigned to** text displays the current status of the selected shortcut key combination. In this case, the text is **[Unassigned]**. Keys or key combinations that are already assigned to a command are displayed here. You must remove any existing key combination that conflicts with your choice before that key combination can be assigned to a new command.

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6.　Click **Assign**.
　　The new shortcut key appears under **Current Keys**.

7.　Click **Close**.

You can now access the **Histogram** gallery by pressing **Ctrl+Shift+H**.

Tip　For a list of Minitab's default shortcut keys, choose **Help** > **Keyboard Map** or go to **Shortcut keys** in the Minitab Help index. To access the Minitab Help index, open Minitab, choose **Help** > **Help**, then click the **Index** tab in the left pane.

Restore Minitab's default options

Any options that you change, as well as any changes that you make to date/time settings or value order settings, are stored in a profile. You can enable and disable this profile using **Tools** > **Manage Profiles**. You also can export and share this profile with other users.

All options that you adjusted while you worked through *Getting Started with Minitab 17* are already stored in your active profile. Disable the current profile to restore Minitab's default options and change the name of the profile to use for future shipping center analyses.

1.　Choose **Tools** > **Manage Profiles**.
2.　Move *MyProfile* from **Active profiles** to **Available profiles**.
3.　In **Available profiles**, double-click *MyProfile* and enter *ShippingCenterAnalysis*.
4.　Click **OK**.

The default options are now restored. Minitab creates a new active profile to store any additional changes that you make.

To enable the options that you adjusted during your *Getting Started with Minitab 17* sessions, move the current active profile to **Available profiles**, move *ShippingCenterAnalysis* to **Active profiles**, and then click **OK**.

Note　You can also reset Minitab's default options by double-clicking the shortcut named Restore Minitab Defaults English located in the English folder under the main Minitab 17 folder that is installed on your hard drive. Export any profiles that you want to keep before you run this program.

Save the project

Save all your work in a Minitab project.

1.　Choose **File** > **Save Project As**.
2.　Browse to the folder that you want to save your files in.
3.　In **File name**, enter *MyCustomize*.
4.　Click **Save**.

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