# Minitab® 17

## Getting Started with Minitab 17

Minitab

Release 17.2.0

# Contents

# 1 Introduction

## Objectives

- Learn about the Minitab user interface
- Open and examine a worksheet

## 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
- Use Minitab Help

## 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**

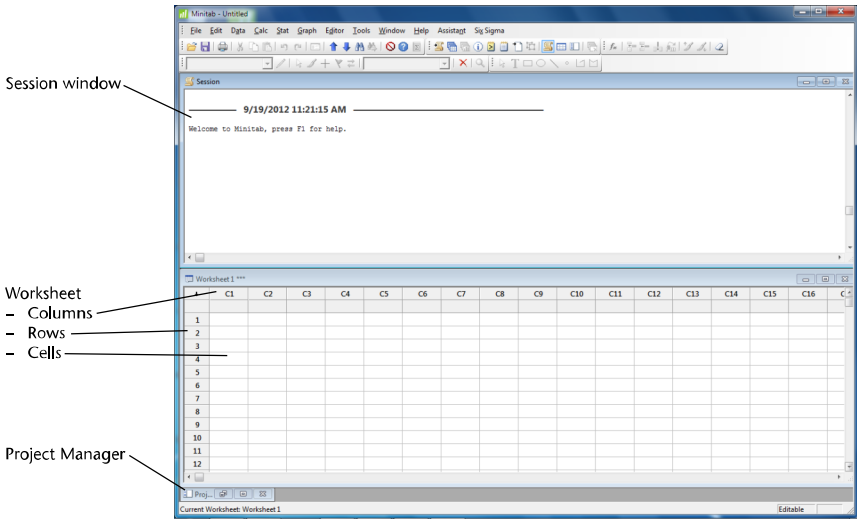
The Session window displays the results of your analyses in text format. Also, in this window, you can enter session commands instead of using Minitab's menus.

**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

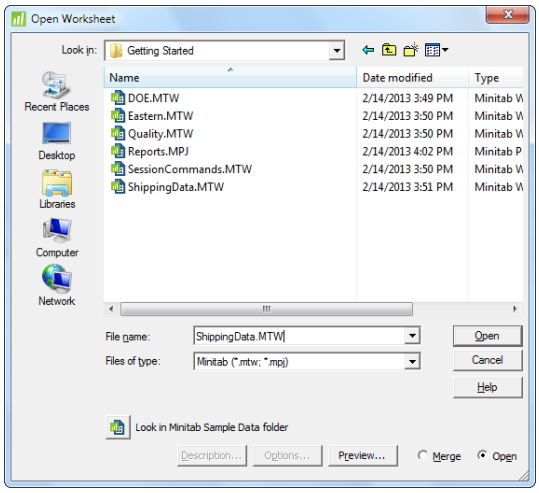
You can open a new, empty worksheet at any time. You can also open one or more files that contain data, such as a Microsoft Excel file. When you open a file, you copy the contents of the file into the current Minitab project. Any changes that you make to the worksheet while you are in the project do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

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

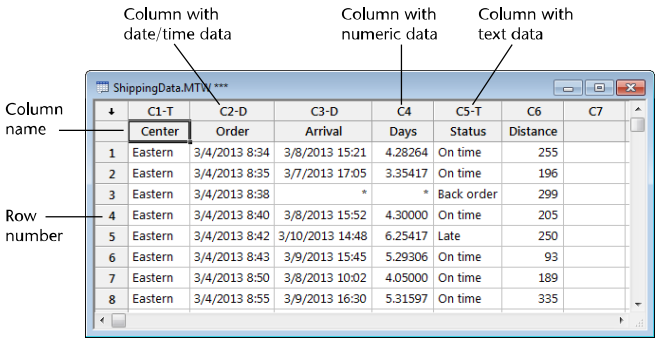
**Note** In some cases, you need to prepare your worksheet before you begin an analysis. For more information, go to Preparing a Worksheet on page 68.

1. Choose **File** > **Open Worksheet**.
2. Near the bottom of the dialog box, click the **Look in Minitab Sample Data folder** button  .
3. In the Sample Data folder, double-click Getting Started.
   You can change the default folder for opening and saving Minitab files by choosing **Tools** > **Options** > **General**.

4. Choose ShippingData.MTW, and then click **Open**.




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

# 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
- Create and interpret scatterplots with the Minitab Assistant
- Arrange multiple graphs on one page
- Save a project

## 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.

## Explore the data

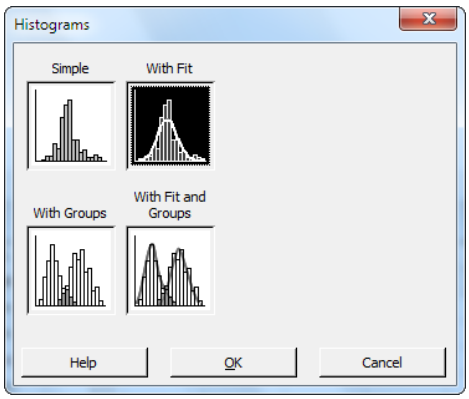
Before you perform a statistical analysis, first create graphs that display important characteristics of the data. For the shipping data, you want to know the mean delivery time for each shipping center and how the data vary within each shipping center. You also want to determine whether the shipping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

### Create a paneled histogram

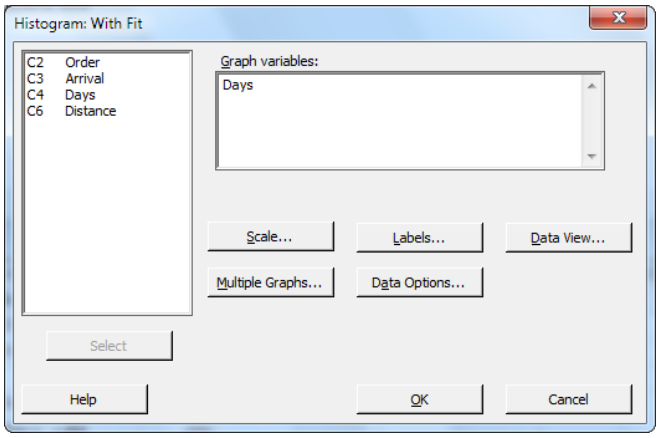
To determine whether the shipping data follow a normal distribution, create a paneled histogram of the time lapse between order date and delivery date.

1. If you are continuing from the previous chapter, go to step 5. If not, start Minitab.
2. Choose **File** > **Open Worksheet**.
3. Near the bottom of the dialog box, click the **Look in Minitab Sample Data folder** button  .

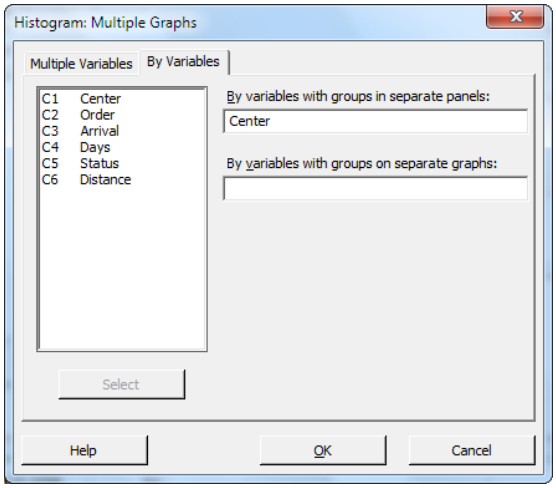
4. In the Sample Data folder, double-click Getting Started, and then choose ShippingData.MTW. Click **Open**.
5. Choose **Graph** > **Histogram**.




6. Choose **With Fit**, and then click **OK**.
7. In **Graph variables**, enter *Days*.




8. Click **Multiple Graphs**, and then click the **By Variables** tab.
9. In **By variables with groups in separate panels**, enter *Center*.



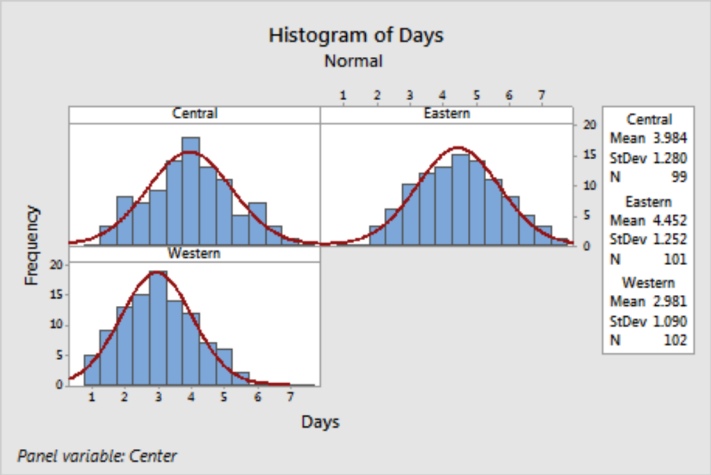
10. Click **OK** in each dialog box.

**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

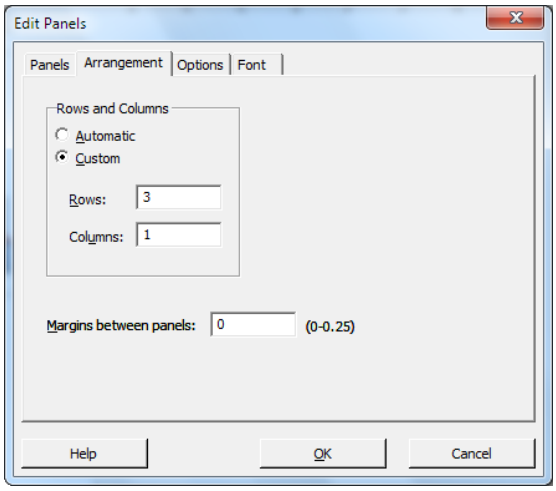
The histograms seem to be approximately bell-shaped and symmetric about the means, which indicates that the delivery times for each center are approximately normally distributed.

# Rearrange the paneled histogram

For the graph that you created, you want to rearrange the three panels to make it easier to compare the means and variation.

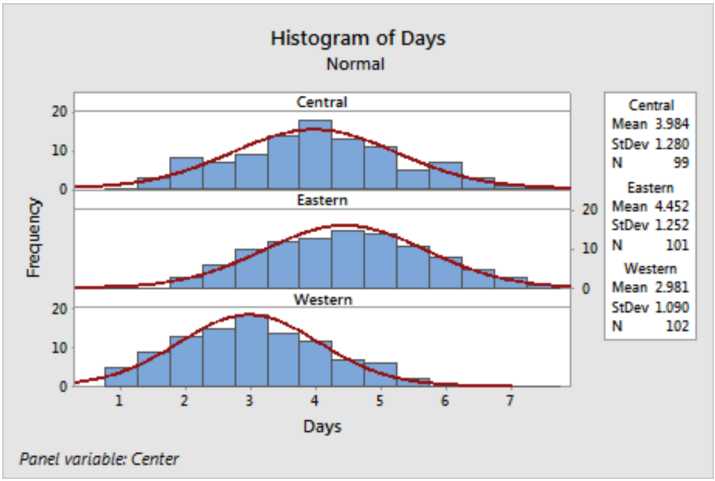
1. Right-click the histogram, and then choose **Panel**.
2. Click the **Arrangement** tab.

3. In **Rows and Columns**, choose **Custom**. In **Rows**, enter *3*. In **Columns**, enter *1*.




4. 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

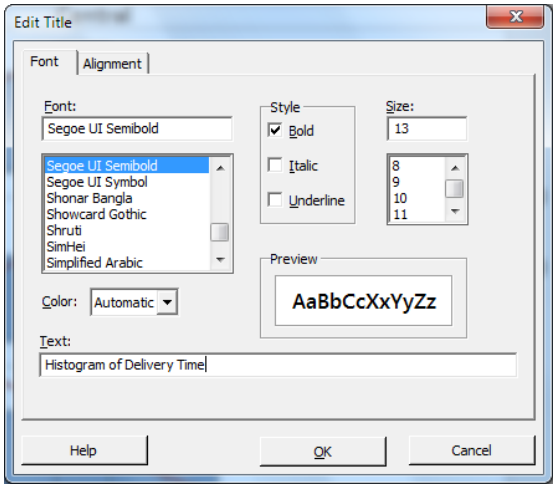
The histogram shows that the Central and Eastern centers are similar in both mean delivery time and spread of delivery time. In contrast, the mean delivery time for the Western center is shorter and the distribution is less spread out. Analyzing Data on page 21 shows how to detect statistically significant 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.

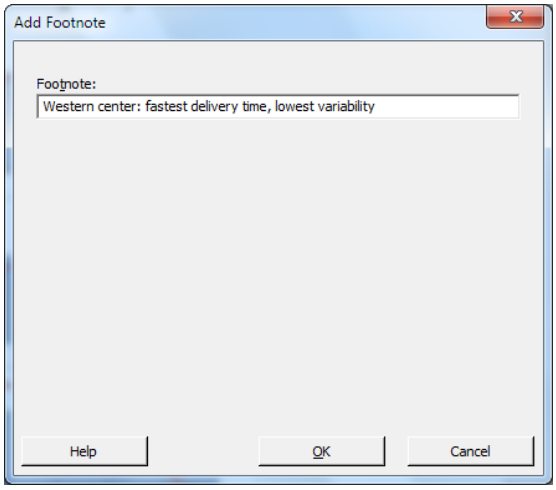
# Edit the title and add a footnote

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*.

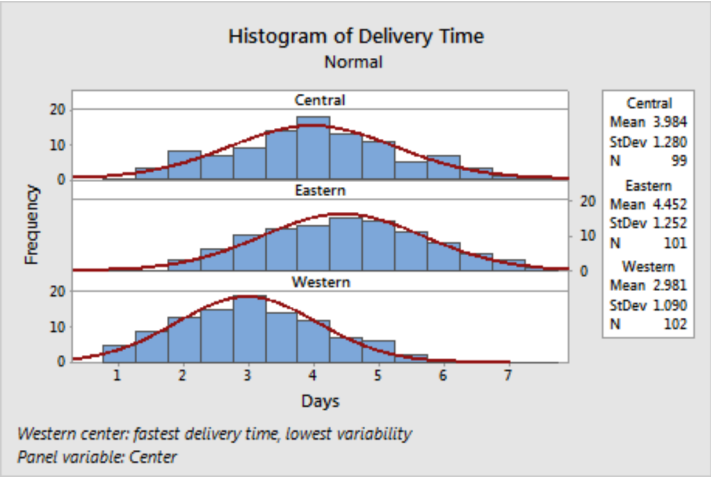



3. Click **OK**.
4. Right-click the histogram, and then choose **Add** > **Footnote**.
5. In **Footnote**, enter *Western center: fastest delivery time, lowest variability*.




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

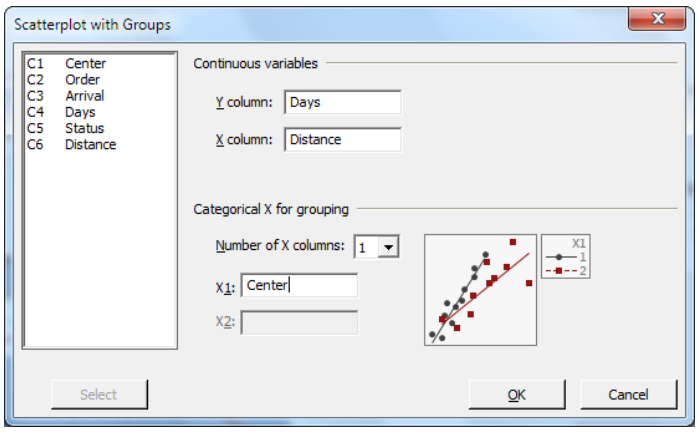
To examine the relationship between two variables, you use a scatterplot. You can choose a scatterplot from the Graph menu or you can use the Minitab Assistant. The Assistant guides you through your analyses and helps you interpret the results with confidence. The Assistant can be used for most basic 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*.

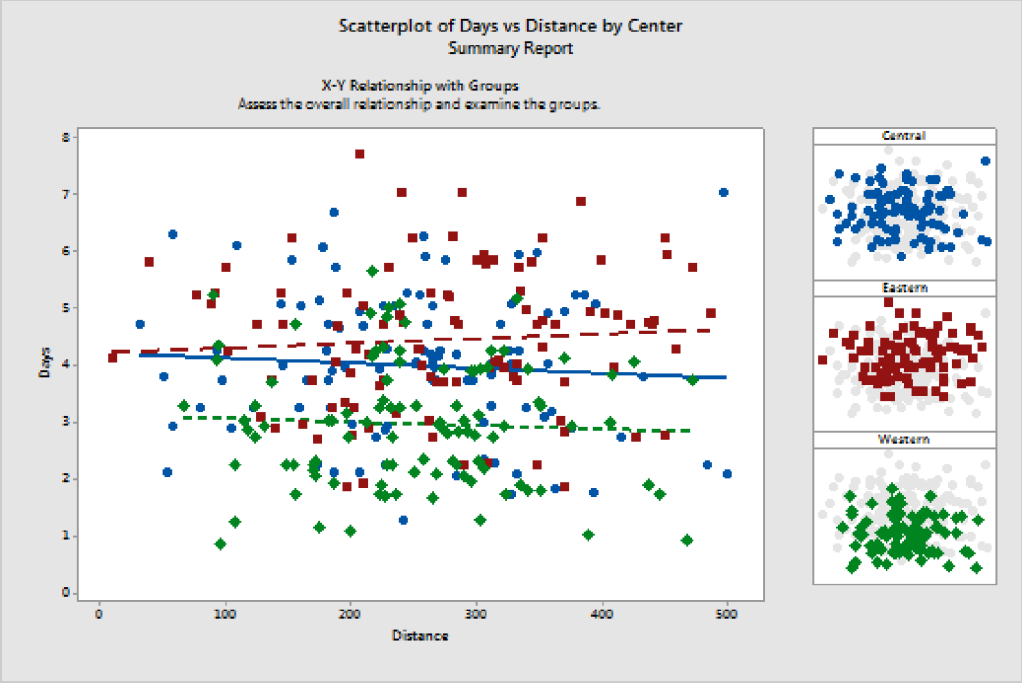
5. In **Number of X columns**, choose **1**.
6. In **X1**, enter *Center*.




7. Click **OK**.

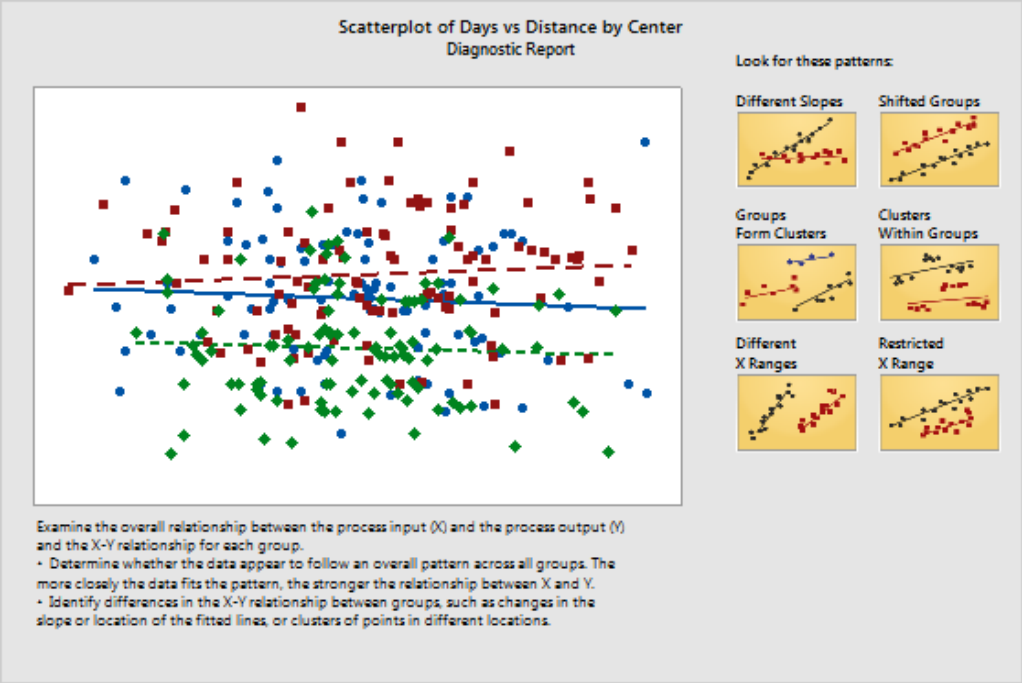
**Summary report**

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.




**Descriptive statistics report**

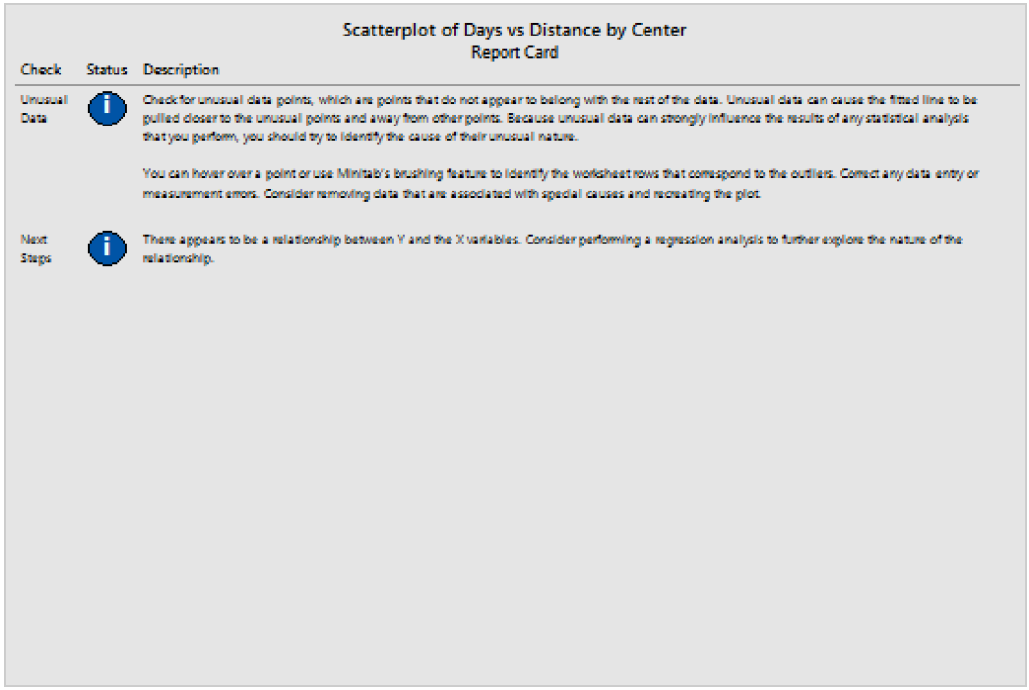
The descriptive statistics report contains descriptive statistics for each shipping center.

Scatterplot of Days vs Distance by Center
Descriptive Statistics Report

| | | Days | | | | Distance | | | |
|---|---|---|---|---|---|---|---|---|---|
| Center | N | 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 21.



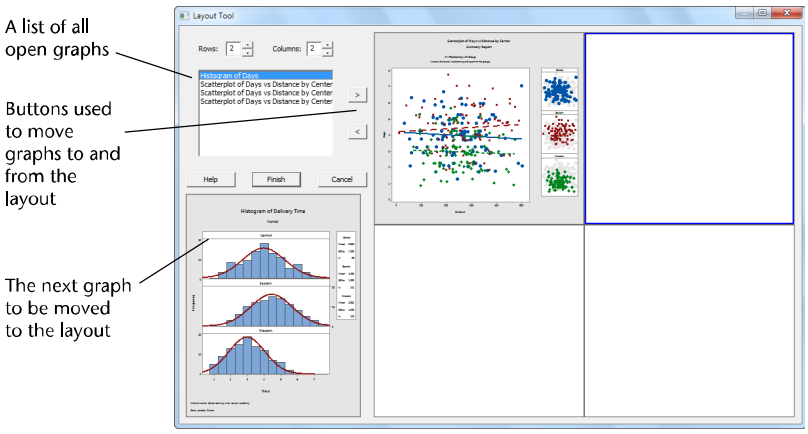

# Arrange multiple graphs on one page

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, and then choose **Editor** > **Layout Tool**.

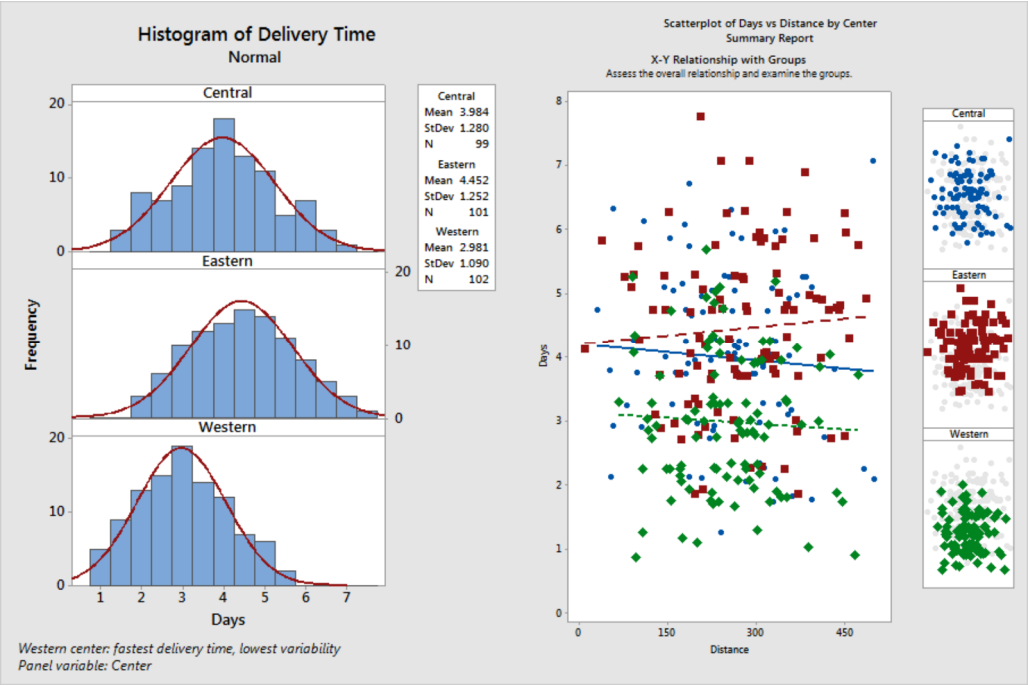



   The scatterplot summary report is already included in the layout.

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 > to place the paneled histogram in the left side of the layout.
5. Click **Finish**.

**Graph layout with the paneled histogram and the scatterplot**



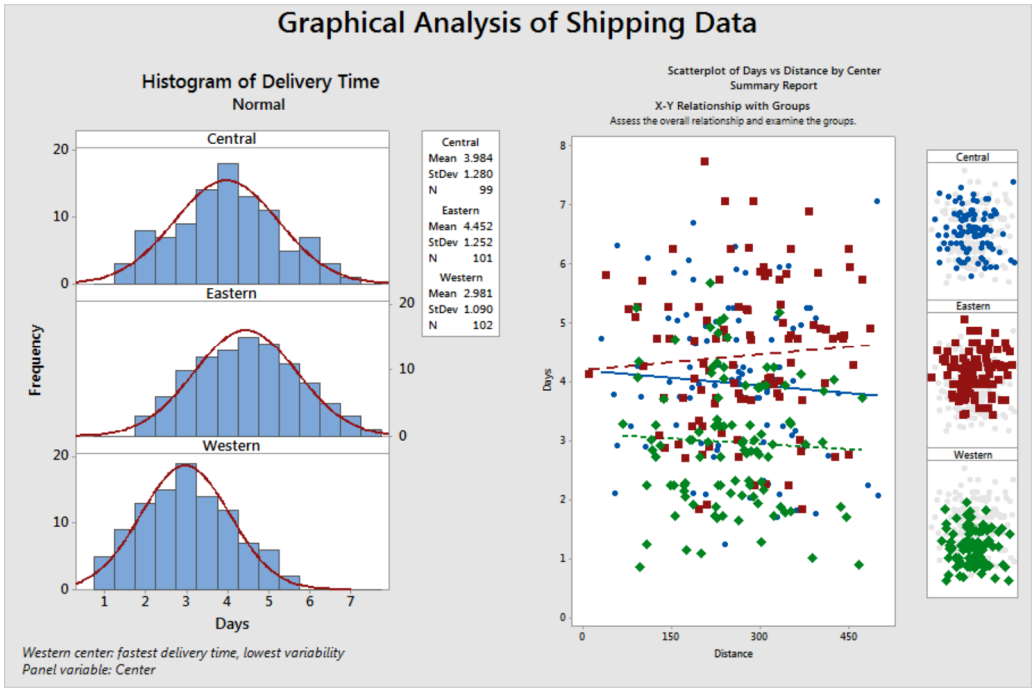

**Note** If you edit the data in the worksheet after you create a layout, Minitab cannot automatically update the graphs in the layout. You must recreate the layout with the new graphs.

# 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.

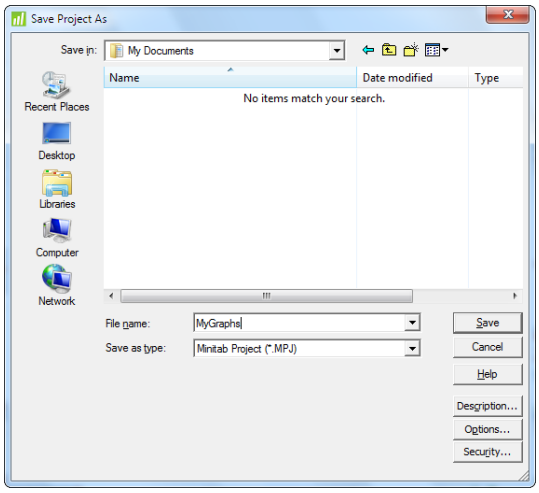
1. Choose **Window** > **Layout**, and then choose **File** > **Print Graph**.
2. Click **OK**.

# 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. Navigate 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

- Summarize the data
- Compare means
- Access StatGuide
- Use the Project Manager

## 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. The inferences then guide your decisions and help you 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.

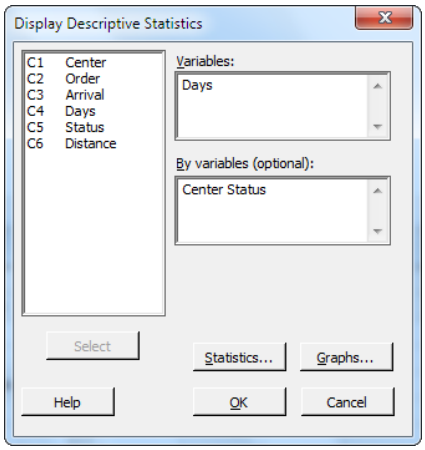
## Summarize the data

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

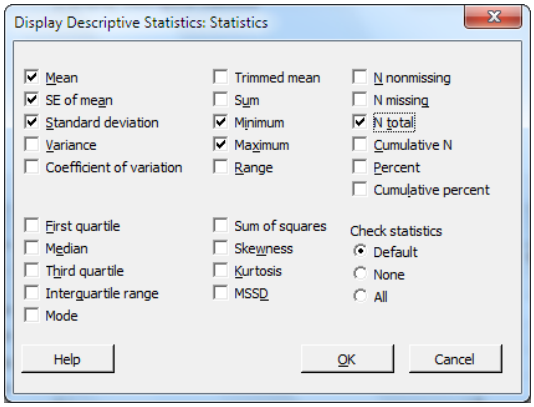
1. If you are continuing from the previous chapter, choose **File** > **New**, select **Minitab Project**, and then click **OK**. If not, start Minitab.
2. Choose **File** > **Open Worksheet**.
3. Near the bottom of the dialog box, click the **Look in Minitab Sample Data folder** button  .
4. In the Sample Data folder, double-click Getting Started, and then choose ShippingData.MTW. Click **Open**.
5. Choose **Stat** > **Basic Statistics** > **Display Descriptive Statistics**.
6. In **Variables**, enter *Days*.

7. 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.

8. Click **Statistics**.
9. Uncheck **First quartile**, **Median**, **Third quartile**, **N nonmissing**, and **N missing**.
10. Check **N total**.




11. 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 choose **Display Descriptive Statistics**. Choose the statistics that you want to display. 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 60.

## 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.

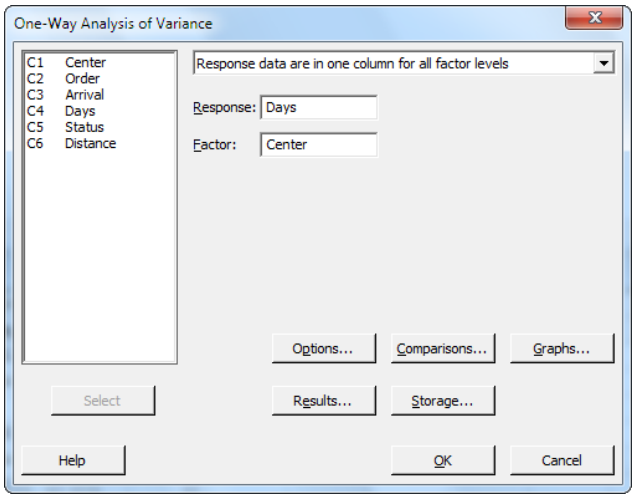
Hypothesis tests include two hypotheses (claims), the null hypothesis ($H_0$) and the alternative hypothesis ($H_1$). The null hypothesis is the initial claim and is often specified based on previous research or common knowledge. The alternative hypothesis is what you believe might be true.

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.

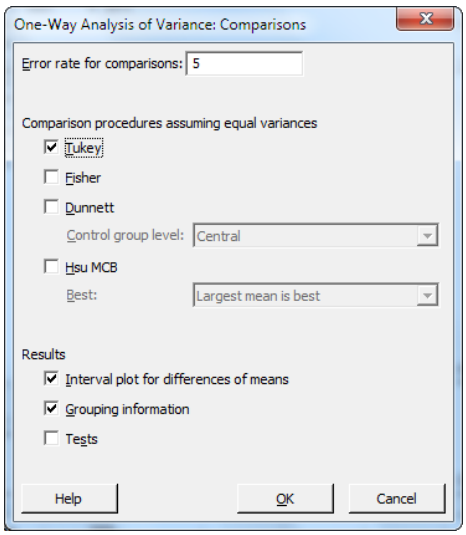
## Perform an ANOVA

1. Choose **Stat** > **ANOVA** > **One-Way**.
2. Choose **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**, check **Tukey**.

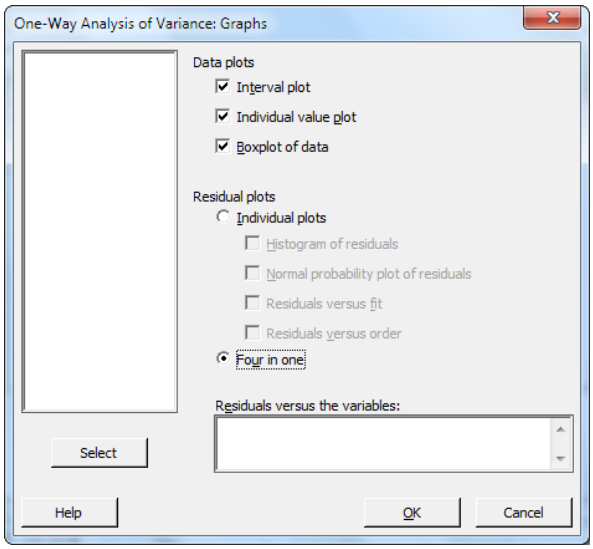



6. Click **OK**.
7. Click **Graphs**.

   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**, check **Interval plot**, **Individual value plot**, and **Boxplot of data**.

9. Under **Residual plots**, choose **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

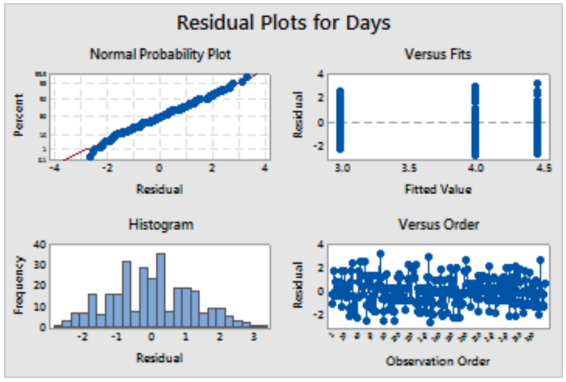
The decision-making process for a hypothesis test is based on the p-value, which indicates the probability of falsely rejecting the null hypothesis when it is really true.

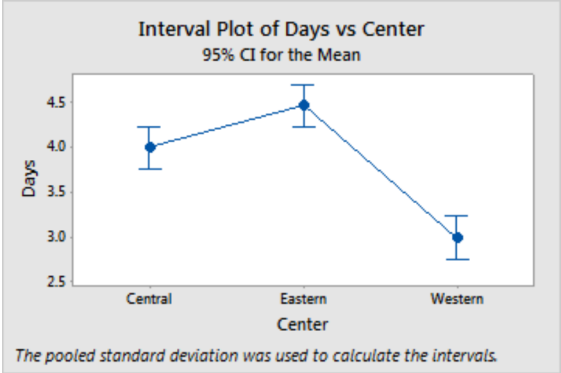
- If the p-value is less than or equal to a predetermined significance level (also known as alpha or α), then you reject the null hypothesis and claim support for the alternative hypothesis.
- If the p-value is greater than α, then you fail to reject the null hypothesis and cannot claim support for the alternative hypothesis.

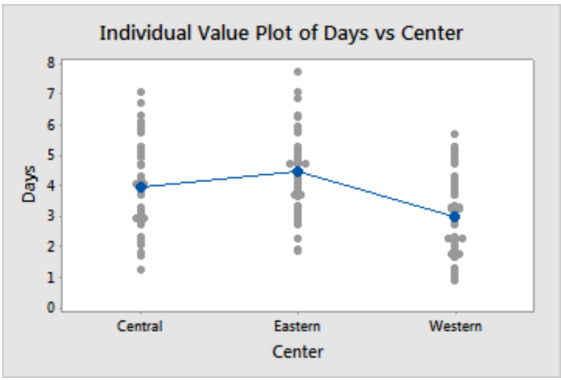
Using α equal to 0.05, the p-value (0.000) in the Analysis of Variance table provides enough evidence to conclude that the average delivery times for at least two of the shipping centers are significantly different.

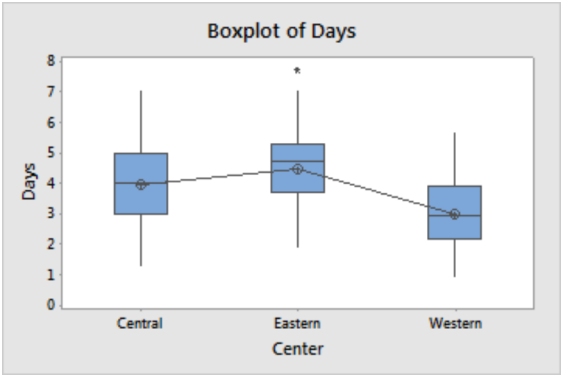
The results of the Tukey's test are included in the grouping information table, which highlights the significant and non-significant comparisons. Because each shipping center is in a different group, all shipping centers have average delivery times that are significantly different from each other.

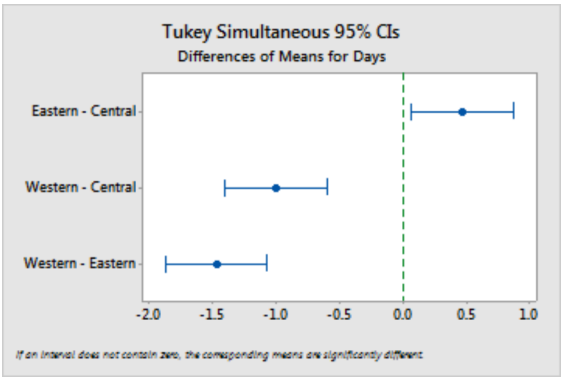
**ANOVA graphs**




Interval Plot of Days vs Center
95% CI for the Mean
Days
4.5
4.0
3.5
3.0
2.5
Central
Eastern
Western
Center
The pooled standard deviation was used to calculate the intervals.


Individual Value Plot of Days vs Center
Days
8
7
6
5
4
3
2
1
0
Central
Eastern
Western
Center


Boxplot of Days
Days
8
7
6
5
4
3
2
1
0
*
Central
Eastern
Western
Center


Tukey Simultaneous 95% CIs
Differences of Means for Days
Eastern - Central
Western - Central
Western - Eastern
-2.0
-1.5
-1.0
-0.5
0.0
0.5
1.0
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, which identifies an outlier or an order that has an unusually long delivery time.

Examine the interval plot again. The interval plot displays 95% confidence intervals for each mean. Pause your cursor over the points on the graph to view the means. Pause your cursor 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:

- 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

Pause your cursor 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 of 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  .
3. In the **Contents** pane, click **Tukey's method**.

**Tip** For more information, go to StatGuide on page 85.

## 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.

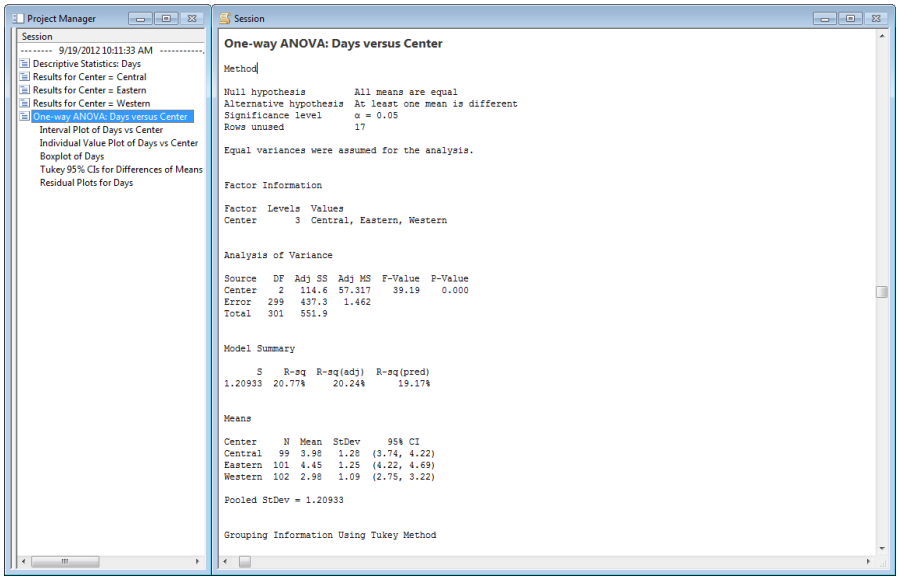
Use the Project Manager to view the statistical analyses that you just performed.

## 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**.

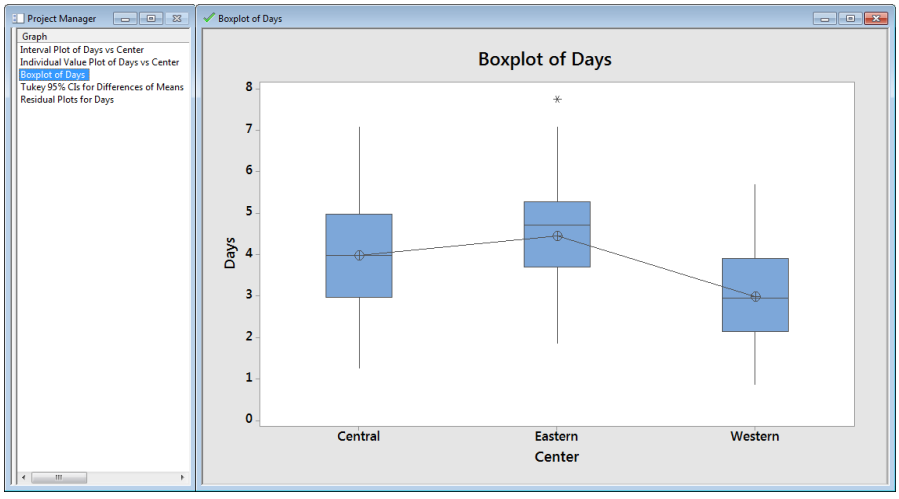



The Project Manager displays the one-way ANOVA session window output in the right pane.

## 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
- Add stages to a control chart
- Update a control chart
- Add date/time labels to a control chart
- Perform and interpret a capability analysis

## 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.

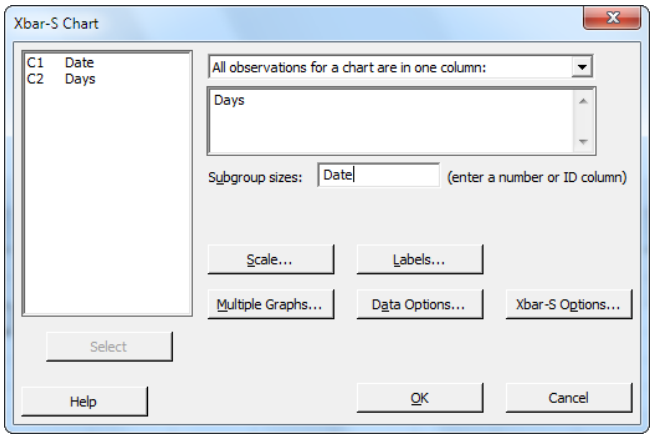
For all control charts, you can modify Minitab's default chart specifications. For example, you can define the estimation method for the process standard deviation, specify the tests for special causes, and display historical stages.

# 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.

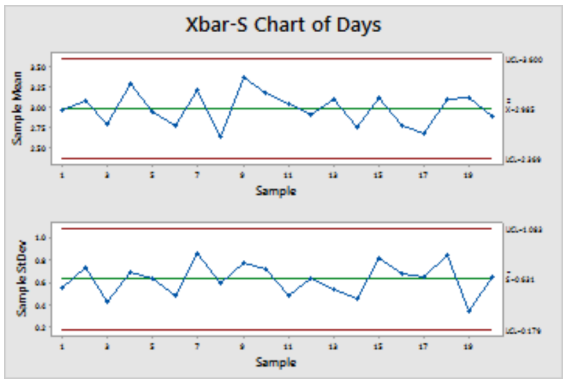
1. If you are continuing from the previous chapter, choose **File** > **New**, select **Minitab Project**, and then click **OK**. If not, start Minitab.
2. Choose **File** > **Open Worksheet**.
3. Near the bottom of the dialog box, click the **Look in Minitab Sample Data folder** button  .
4. In the Sample Data folder, double-click Getting Started, and then choose Quality.MTW. Click **Open**.
5. Choose **Stat** > **Control Charts** > **Variables Charts for Subgroups** > **Xbar-S**.
6. Choose **All observations for a chart are in one column**, and then enter *Days*.
7. 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.

8. Click **OK**.

**Xbar-S chart**




**Tip** Pause your cursor 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

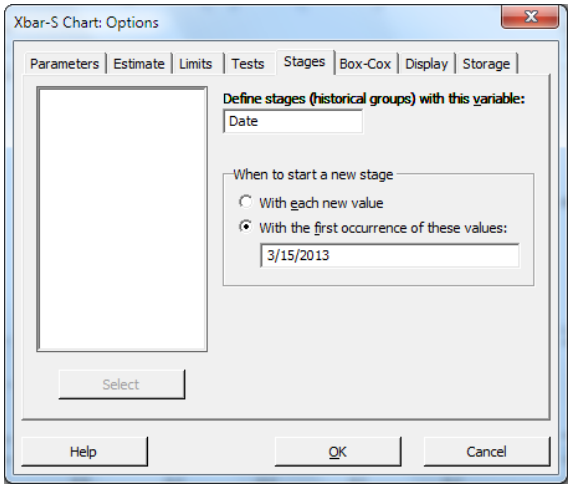
You can use stages on a control chart to show how a process changes over specific periods of time. At each stage, Minitab recalculates the center line and control limits.

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**.

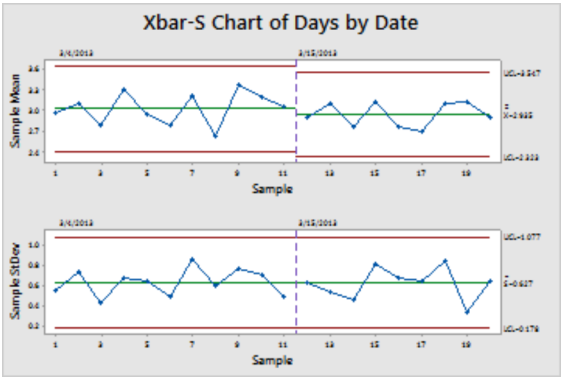
   **Tip** Minitab saves your dialog box settings with your project. To reset a dialog box, press **F3**.

2. Click **Xbar-S Options**, and then click the **Stages** tab.
3. In **Define stages (historical groups) with this variable**, enter *Date*.
4. Under **When to start a new stage**, choose **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 of the points on the control chart are within the control limits before and after the process change. For the second stage, the process mean ($\bar{\bar{X}}$) is 2.935 and the average standard deviation ($\bar{S}$) 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**, and then click the **Display** tab. Under **Other**, check **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) without re-creating the graph.

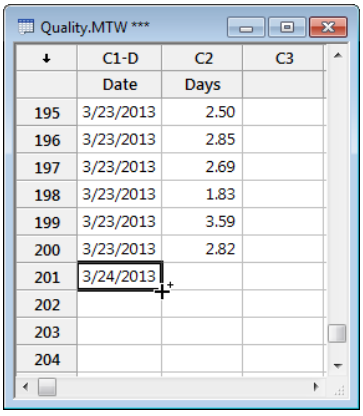
After you create the Xbar-S chart, the manager of the Western shipping center gives you more data, which was collected on 3/24/2013. Add the data to the worksheet and update the control chart.

## 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.

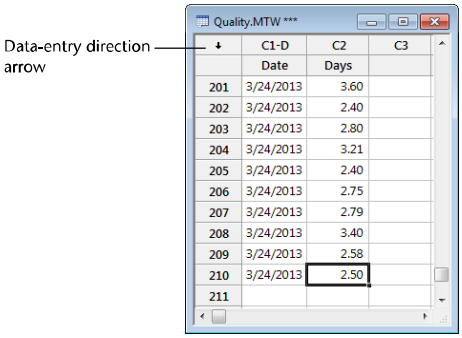
3. To add the date, 3/24/2013, to rows 201–210:
   a. Enter *3/24/2013* in row 201 in C1.
   b. Select the cell that contains 3/24/2013, and point to the Autofill handle in the lower-right corner of the cell. When the pointer becomes a cross symbol ( + ), press **Ctrl** and drag the pointer to row 210 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.




| | C1-D | C2 | C3 |
|---|---|---|---|
| | Date | Days | |
| 195 | 3/23/2013 | 2.50 | |
| 196 | 3/23/2013 | 2.85 | |
| 197 | 3/23/2013 | 2.69 | |
| 198 | 3/23/2013 | 1.83 | |
| 199 | 3/23/2013 | 3.59 | |
| 200 | 3/23/2013 | 2.82 | |
| 201 | 3/24/2013 | | |
| 202 | | | |
| 203 | | | |
| 204 | | | |

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.



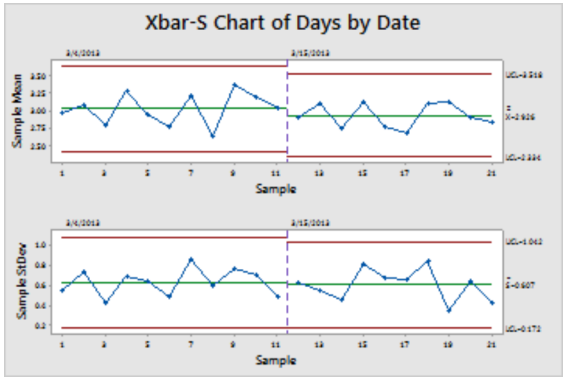

| | C1-D | C2 | C3 |
|---|---|---|---|
| | Date | Days | |
| 201 | 3/24/2013 | 3.60 | |
| 202 | 3/24/2013 | 2.40 | |
| 203 | 3/24/2013 | 2.80 | |
| 204 | 3/24/2013 | 3.21 | |
| 205 | 3/24/2013 | 2.40 | |
| 206 | 3/24/2013 | 2.75 | |
| 207 | 3/24/2013 | 2.79 | |
| 208 | 3/24/2013 | 3.40 | |
| 209 | 3/24/2013 | 2.58 | |
| 210 | 3/24/2013 | 2.50 | |
| 211 | | | |

5. Verify that you entered the data correctly.

## Update the control chart

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

**Updated Xbar-S chart showing the new subgroup**



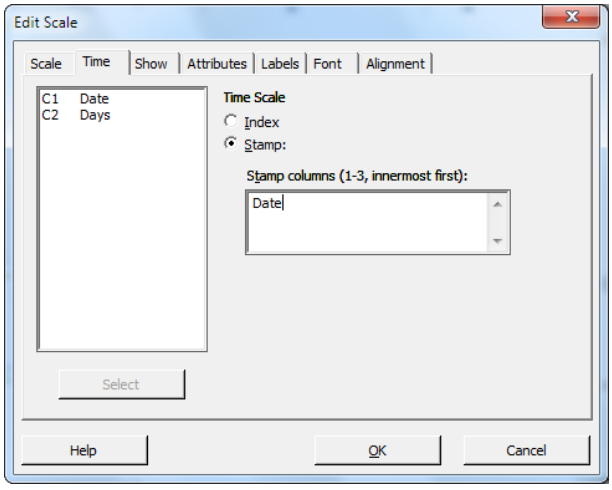

The Xbar-S chart now includes the new subgroup. The mean ($\overline{X}$ = 2.926) and standard deviation ($\overline{S}$ = 0.607) have changed slightly, but the process still appears to be in control.

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

# Change the x-axis labels to dates

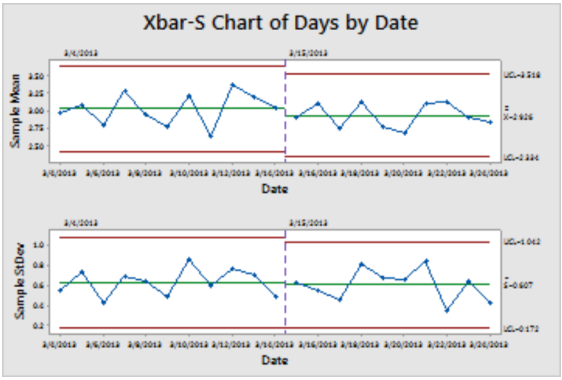
By default, the subgroups on Xbar-S charts are labeled in consecutive numeric order. You can edit the x-axis to display dates instead.

1. Double-click the x-axis on the Xbar chart (the top chart).
2. In the **Edit Scale** dialog box, click the **Time** tab, and then under **Time Scale**, choose **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.

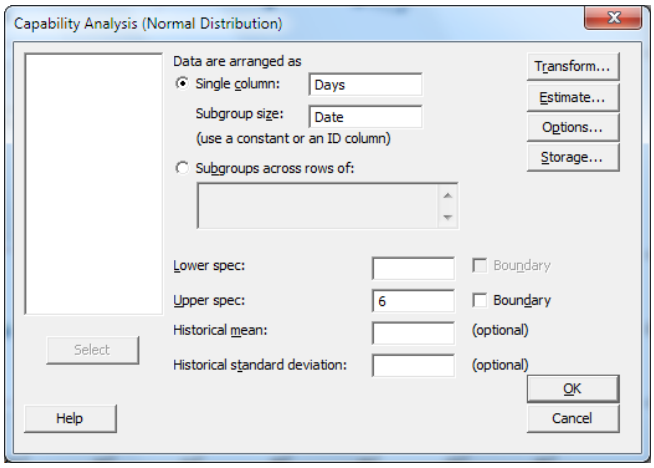
Capability indices, or statistics, are a simple way of assessing process capability. Because capability indices reduce process information to single numbers, comparing one process to another is easy.

## 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.

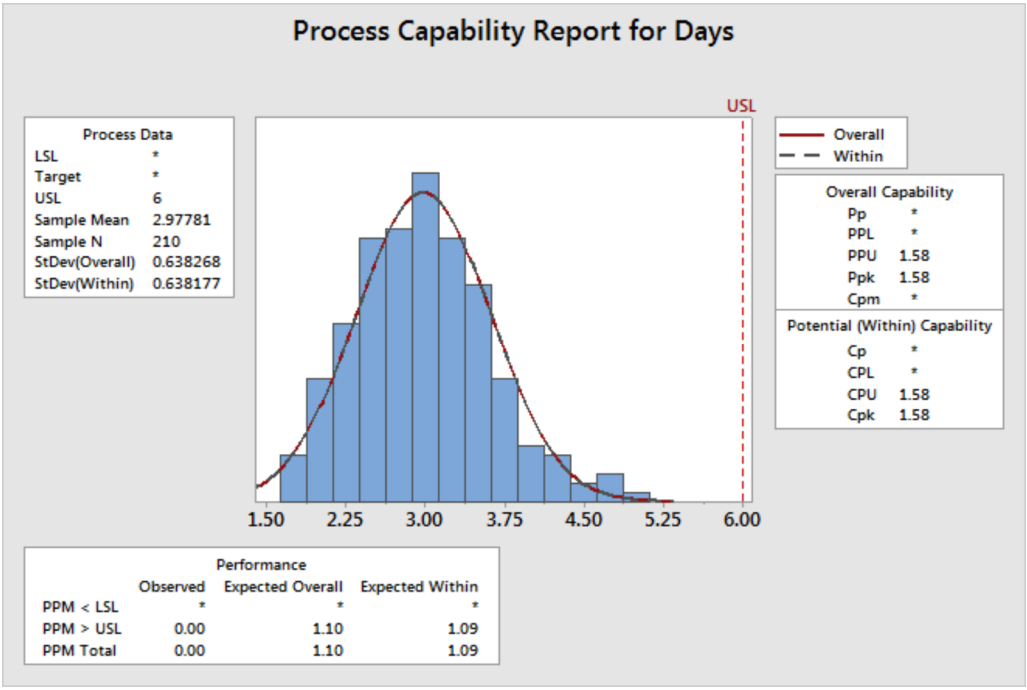
1. Choose **Stat** > **Quality Tools** > **Capability Analysis** > **Normal**.
2. Under **Data are arranged as**, choose **Single column**. Enter *Days*.
3. In **Subgroup size**, enter *Date*.

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 of 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 *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.