TUTORIAL FOR CREATING AND ANALYZING A SCREENING DESIGN WITH STATGRAPHICS PLUS

Creating and Analyzing a Screening Design

In this tutorial, which is adapted from an experiment by Vardeman (1994) in *Statistics for Engineering Problem Solving*, you will study flight distances of paper airplanes.

Four primary factors are thought to influence the distance the planes fly when launched from a prefabricated launcher:

- design of the plane (straight or tee)
- use of a paper clip on the nose (yes or no)
- type of paper (construction or notebook)
- type of wing tips (straight or bent).

To duplicate this experiment, you will use a 2^4 factorial design (four factors, each having two different levels). The response variable is **Distance**, which represents the mean flight distance for two launches of each plane.

To begin, open STATGRAPHICS *Plus* and the **Plane** data file.

Creating the Design

1. Choose SPECIAL... EXPERIMENTAL DESIGN... CREATE DESIGN... from the Menu bar to display the Create Design Options dialog box.

2. Accept Screening as the Design Class default.

3. Accept the default, 1, in the No. of Response Variables text box.

4. Type *4* in the Number of Experimental Factors text box.

5. Type ***Airplane Experiment*** in the Comment text box.

   This name will appear on reports and graphs when you analyze the experiment. Your dialog box should now look like the one shown in Figure 1-1.

6. Click OK to display the Factor Definition Options dialog box.

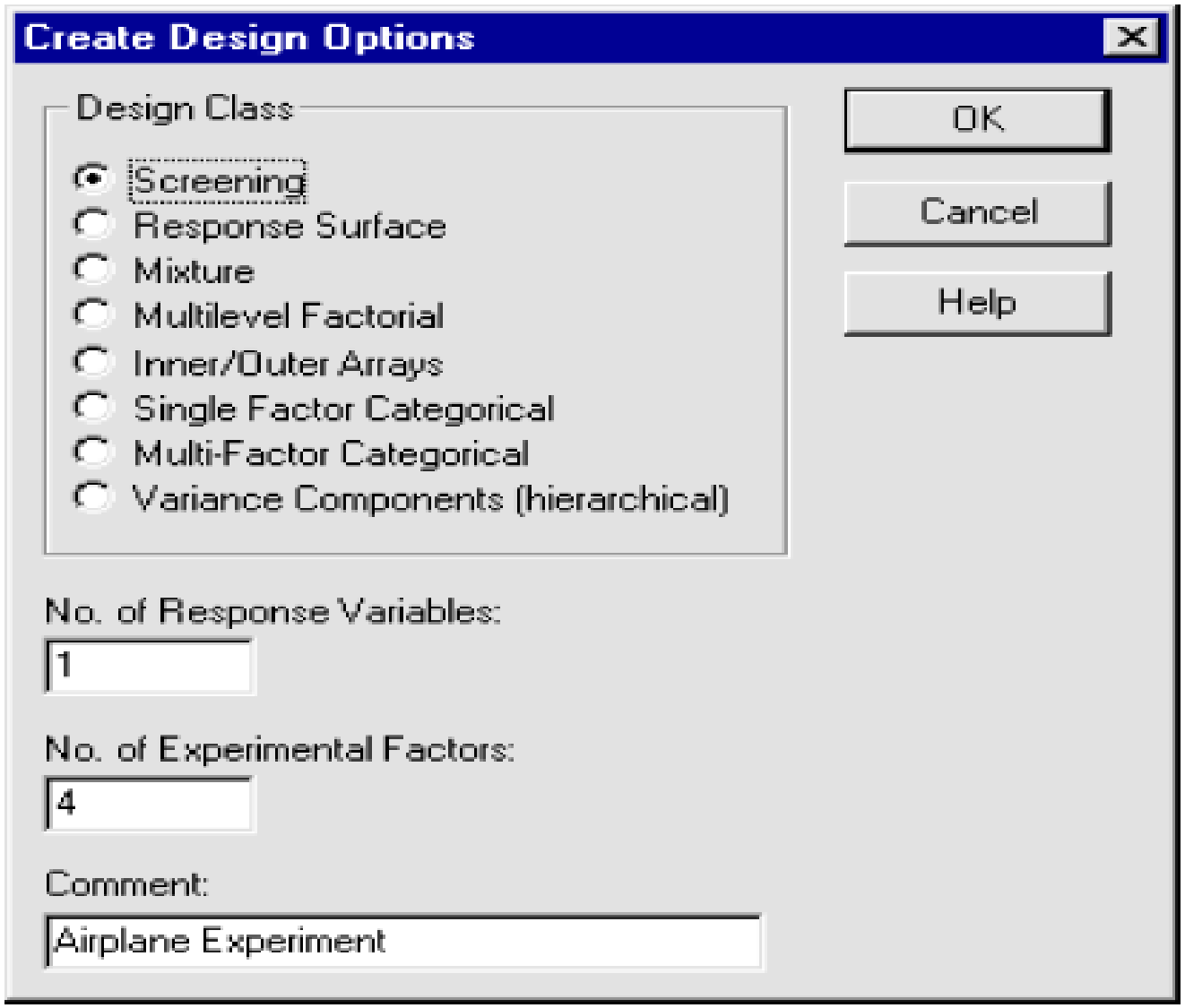

Figure 1-1. Completed Create Design Options Dialog Box (Screening Design)

7. Complete the dialog box for Factor A: Type ***Design*** in the Name text box, ***Straight*** in the Low text box, ***Tee*** in the High text box, leave the Units text box blank, and the Continuous check box deselected (see Figure 1-2).

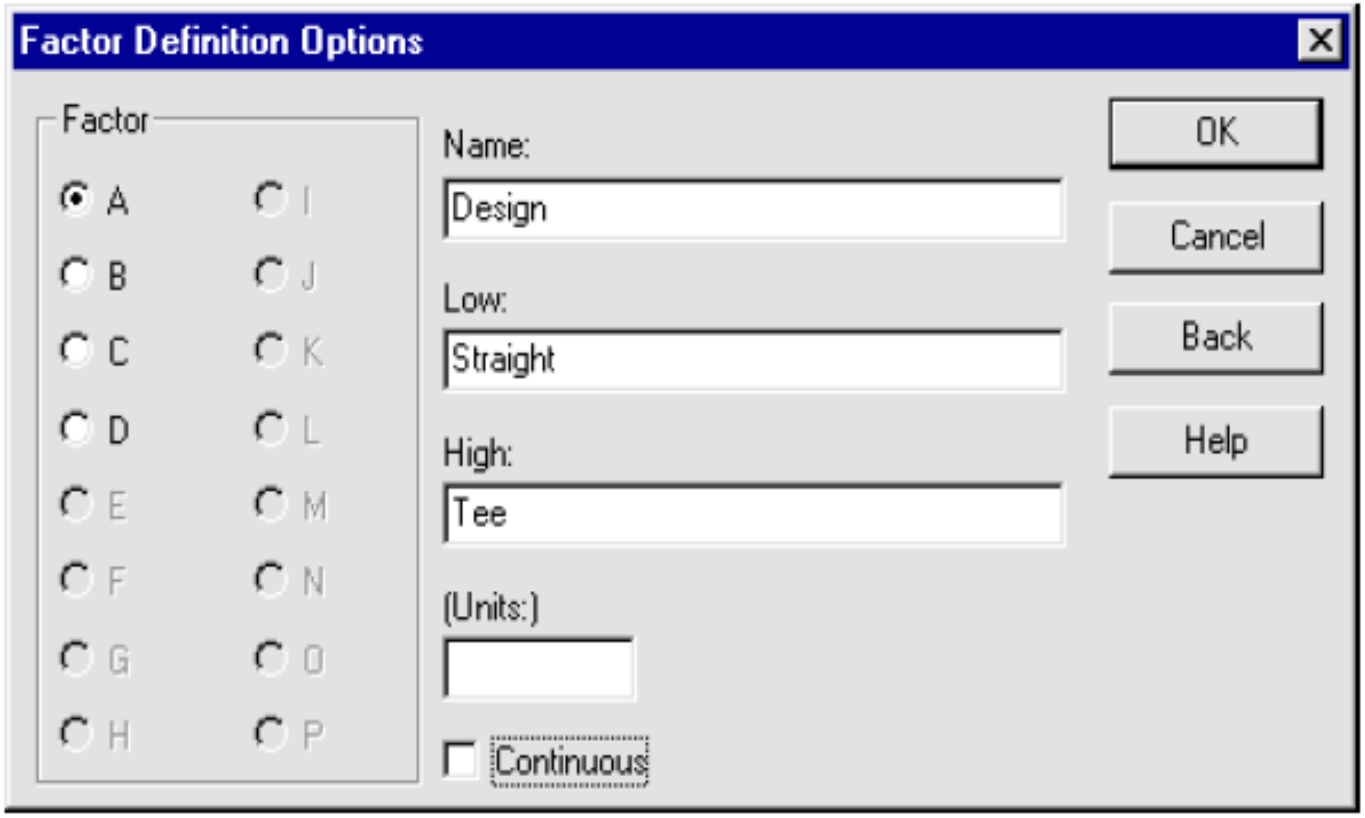

Figure 1-2. Completed Dialog Box for Factor A

8. Complete the dialog box for Factor B: Click the Factor B option, type ***Nose*** in the Name text box, ***None*** in the Low text box, ***Clip*** in the High text box, leave the Units text box blank, and the Continuous check box deselected (see Figure 1-3).

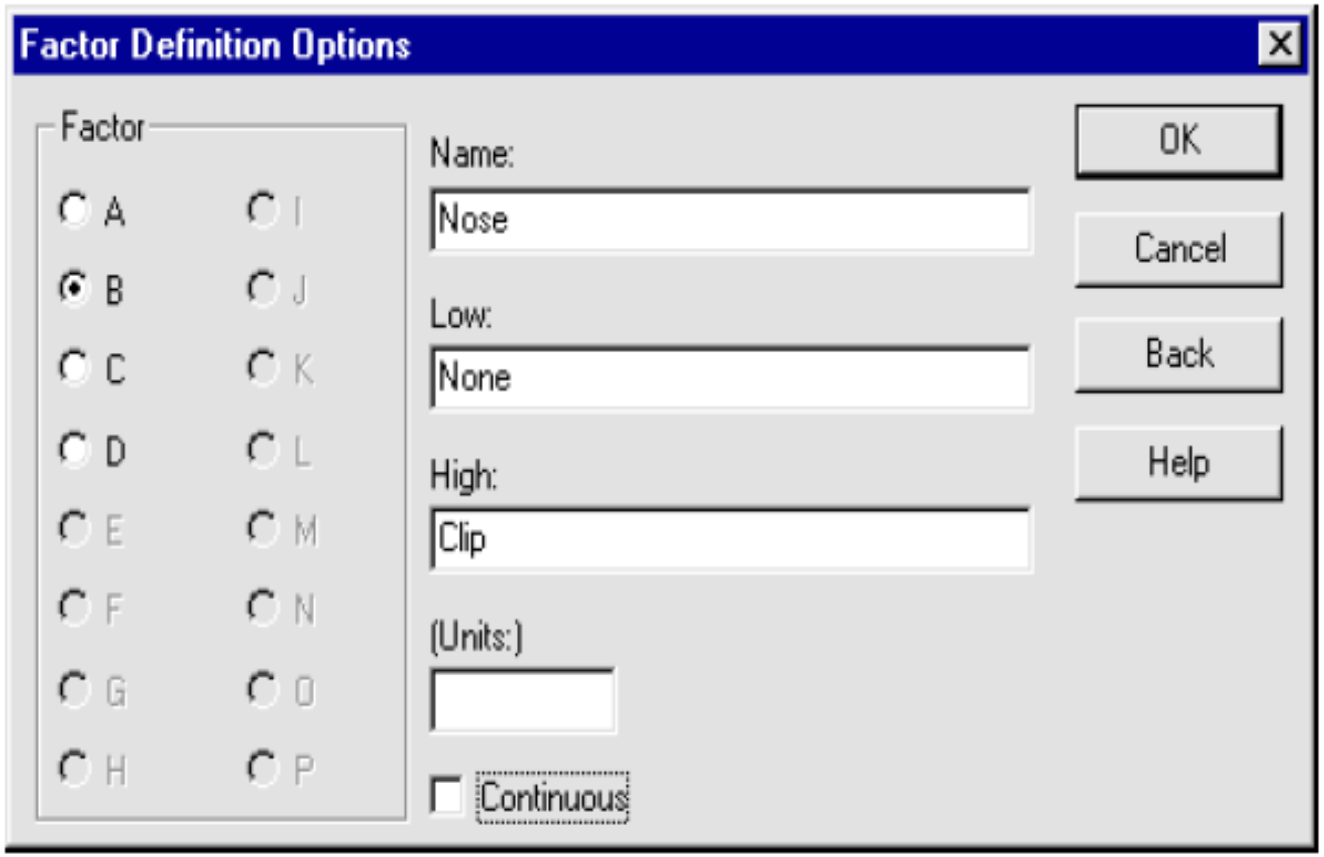

Figure 1-3. Completed Dialog Box for Factor B

9. Complete the dialog box for Factor C: Click the Factor Coption, type ***Paper*** in the Name text box, ***Notebook*** in the Low text box, ***Construct*** in the High text box, leave the Units text box blank, and the Continuous check box deselected (see Figure 1-4).

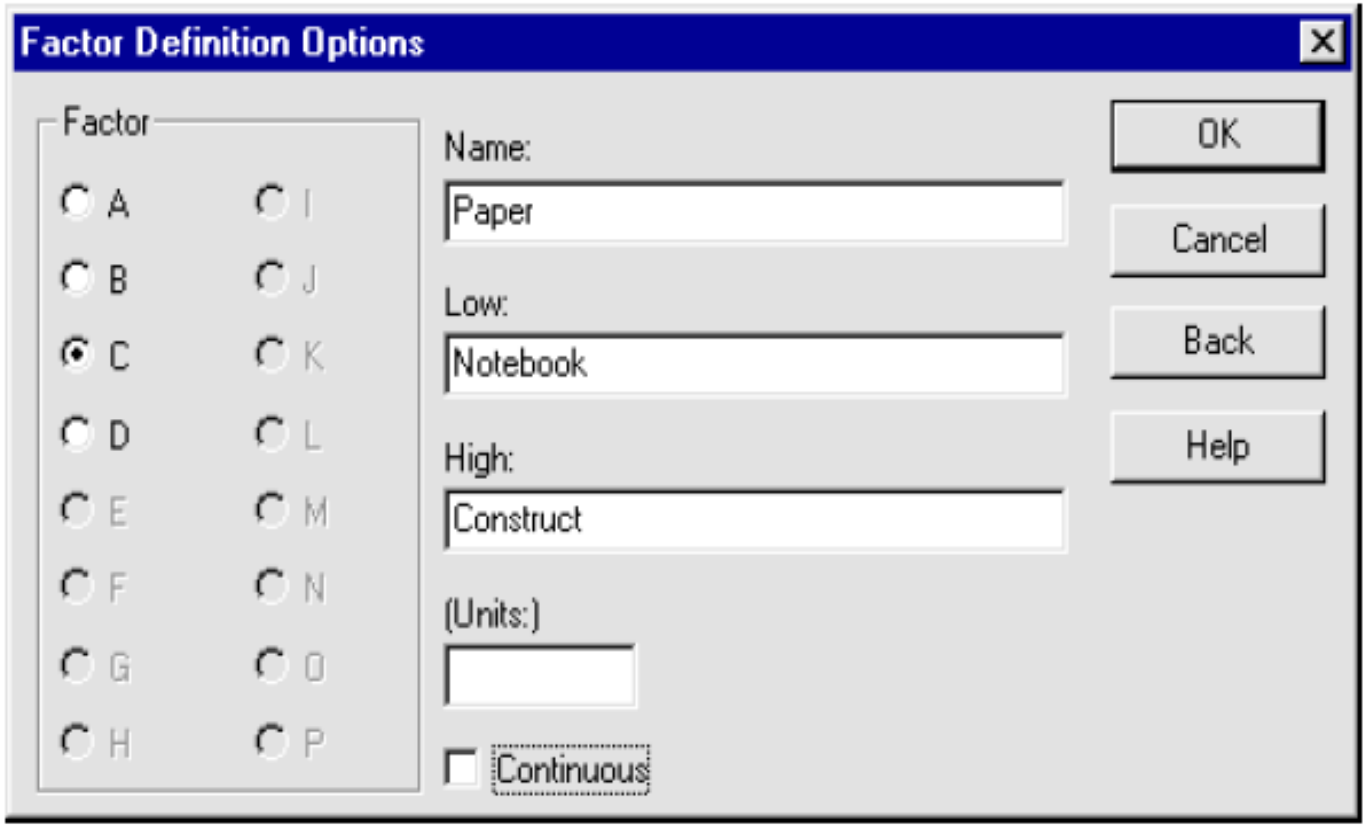

Figure 1-4. Completed Dialog Box for Factor C

10. Complete the dialog box for Factor D: Click the Factor D option, type ***Wing*** in the Name text box, ***Straight*** in the Low text box, ***Bent*** in the High text box, leave the Units text box blank, and the Continuous check box deselected (see Figure 1-5).

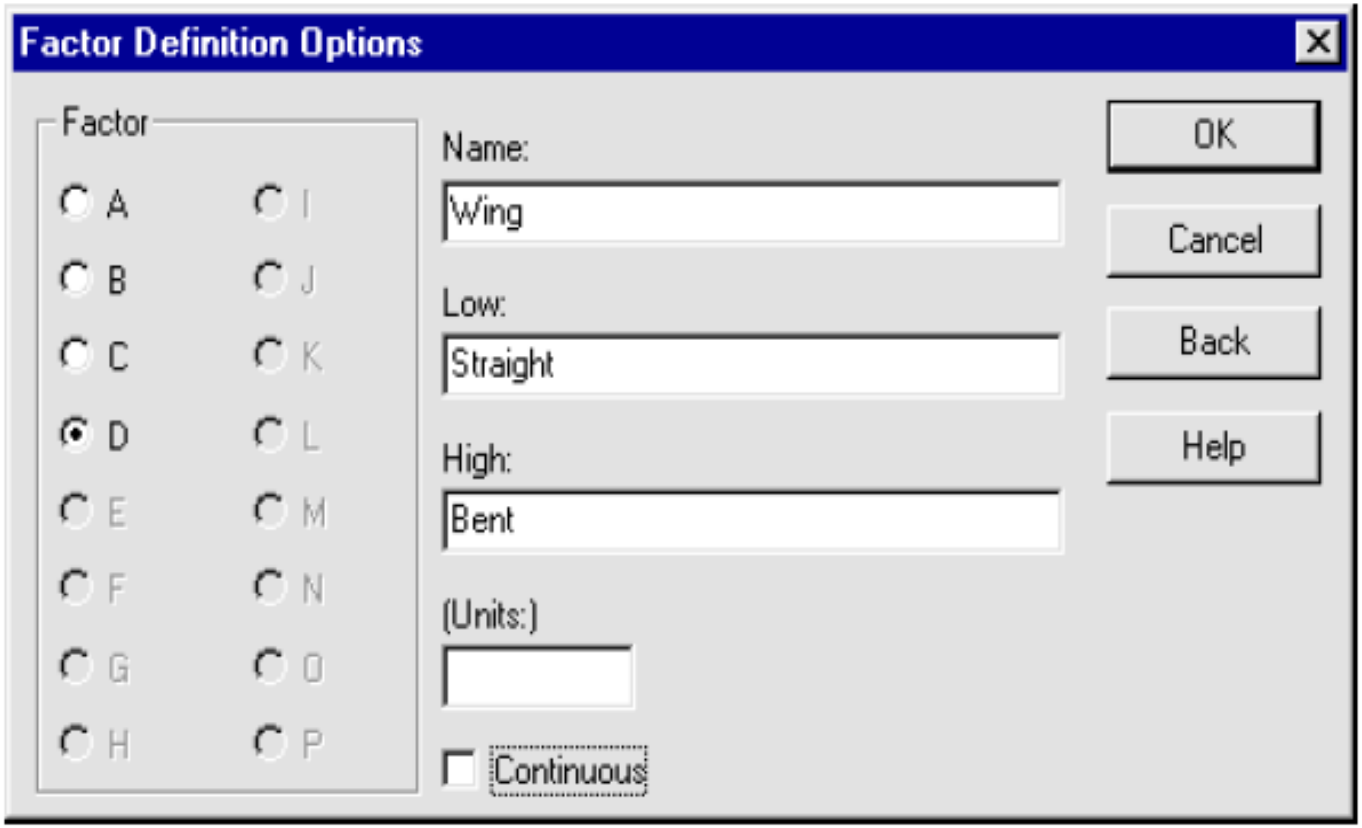

Figure 1-5. Completed Dialog Box for Factor D

11. Click OK to display the Response Definition Options dialog box.

12. Type ***Distance*** in the Name text box.

13. Type ***Feet*** in the Units text box.

    The dialog box should look like the one shown in Figure 1-6.

14. Click OK to display the Screening Design Selection dialog box.

15. Use the down arrow to display the available designs, then choose ***Factorial in 2 blocks*** (see Figure 1-7).

16. Click OK to display the Blocked Screening Design Options dialog box.

    Notice that the name of the base design (Factorial 2^4) appears on the first line of the dialog box. Beneath that, the number of runs and error degrees of freedom are shown.

17. Deselect the Randomize check box so the design will be created in standardized order to make it easier to enter data then accept the other defaults (see Figure 1-8).

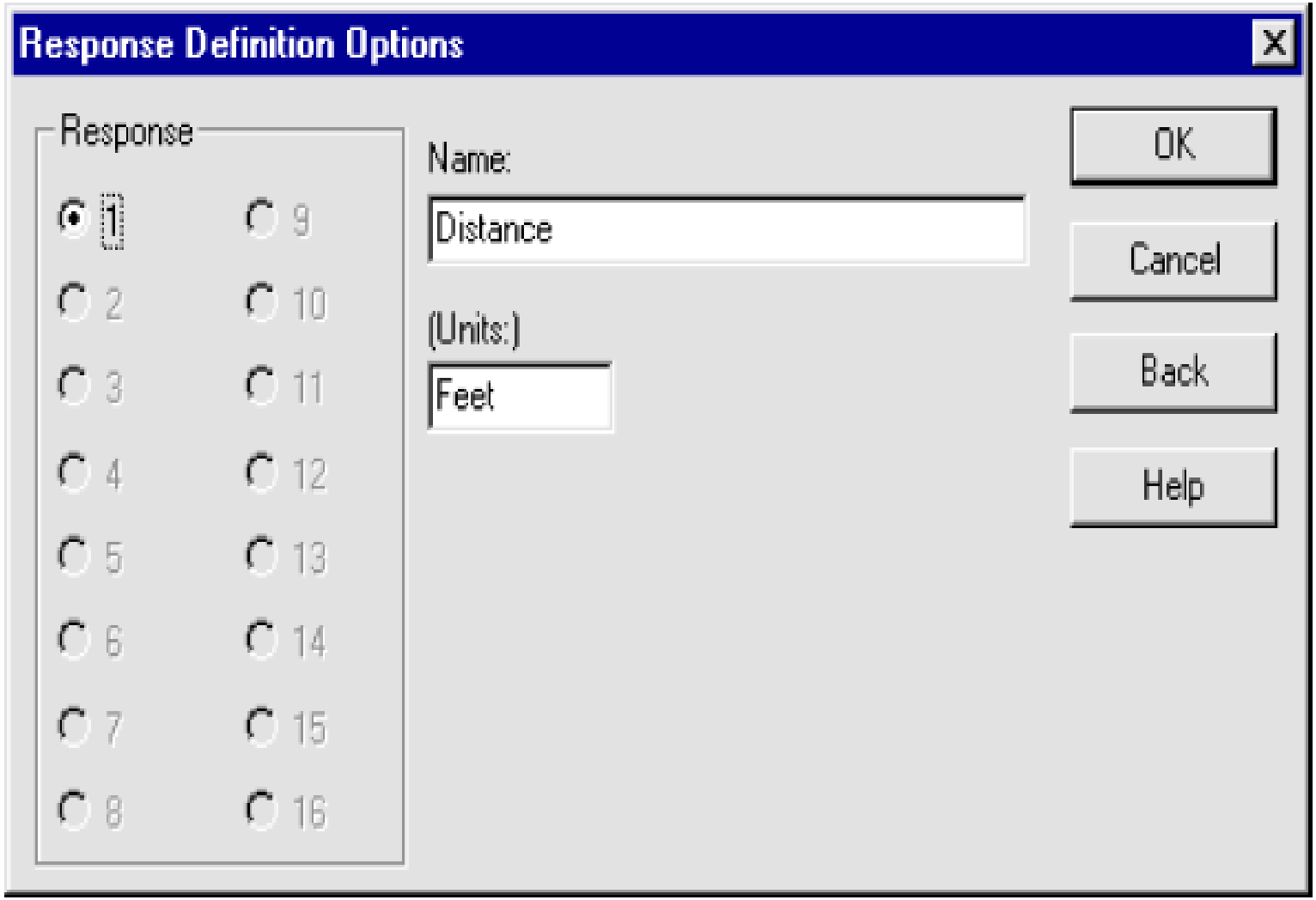

Figure 1-6. Completed Response Definition Options Dialog Box

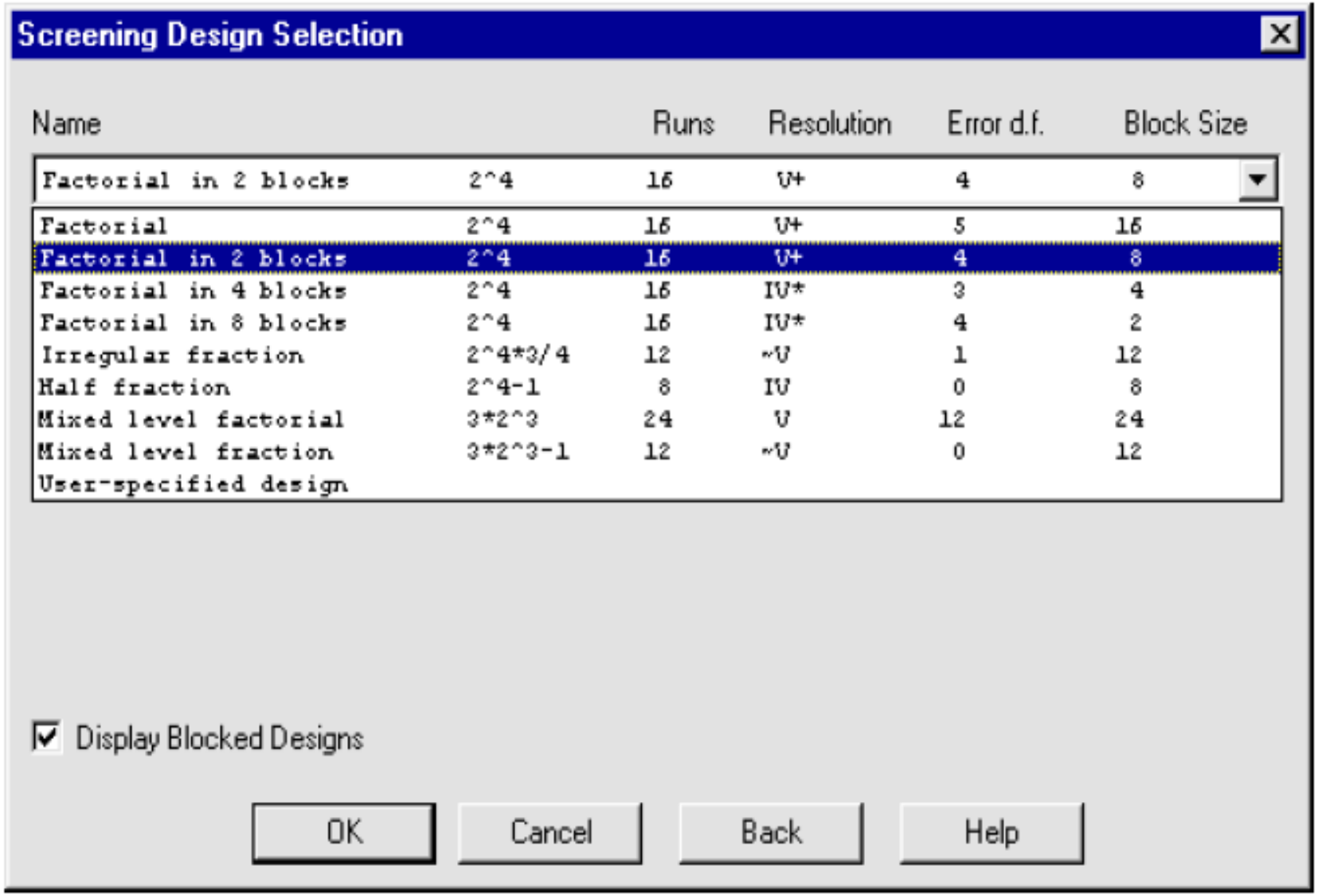

Figure 1-7. Screening Design Selection Dialog Box with Chosen Design

Note: In a typical experiment, you would normally randomize the design.

18. Click OK to display the Design Summary in the Screening Design Attributes window (see Figure 1-9).

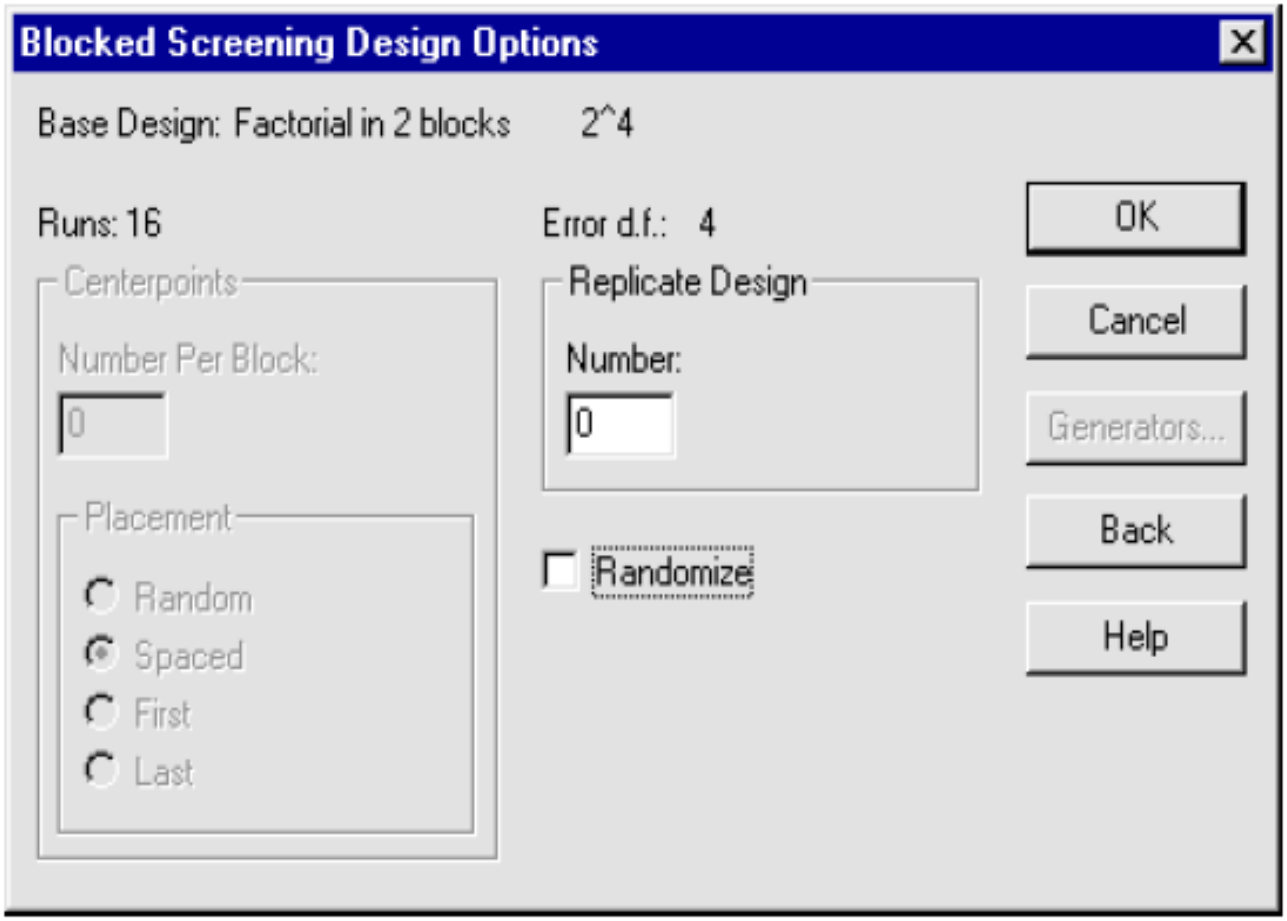

Figure 1-8. Completed Blocked Screening Design Options Dialog Box

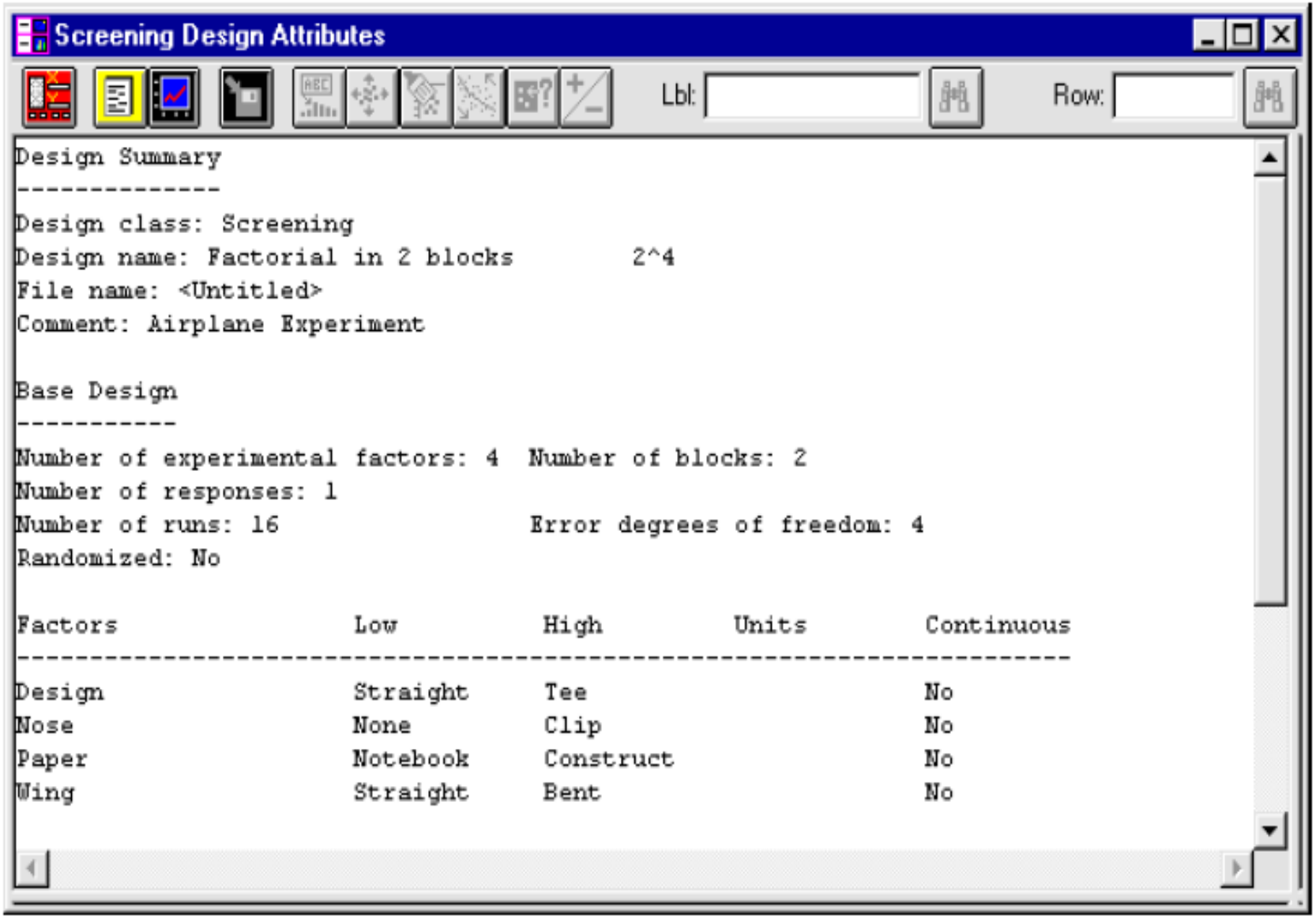

Figure 1-9. Design Summary

The Design Summary includes the name of the design and its class, and the comment you entered about the experiment. If you have not yet saved the design, the file name will appear as <Untitled>. The rest of the information summarizes the factors, responses, runs, blocks, number of centerpoints, and error degrees of freedom.

After reviewing the details of the design, save it.

Naming and Saving the Design

1. Choose FILE... SAVE AS... SAVE DESIGN FILE AS... from the Menu bar to display the Save Design File As dialog box.

2. Type *Plane.sfx* in the Name text box and click the Save button to name and save the file and redisplay the Design Summary.

   Now you are ready to collect and set up the data for the experiment. The design and response values are shown in Table 1-1.

Table 1-1. The Design and Response Values for the Plane.sfx

Design	*Nose*	*Paper*	*Wing*
Tee	None	Notebook	Straight
Straight	Clip	Notebook	Straight
Straight	None	Construct	Straight
Tee	Clip	Construct	Straight
Straight	None	Notebook	Bent
Tee	Clip	Notebook	Bent
Tee	None	Construct	Bent
Straight	Clip	Construct	Bent
Straight	None	Notebook	Straight
Tee	Clip	Notebook	Straight
Tee	None	Construct	Straight
Straight	Clip	Construct	Straight
Tee	None	Notebook	Bent
Straight	Clip	Notebook	Bent
Straight	None	Construct	Bent
Tee	Clip	Construct	Bent

Analyzing the Experimental Results

1. Choose SPECIAL... EXPERIMENTAL DESIGN... ANALYZE DESIGN... from the Menu bar to display the Analyze Design dialog box.

2. Enter Distance into the Data text box and click OK to display the Analysis Summary and the Standardized Pareto Chart in the Analysis window. Maximize the Analysis Summary (see Figure 1-11).

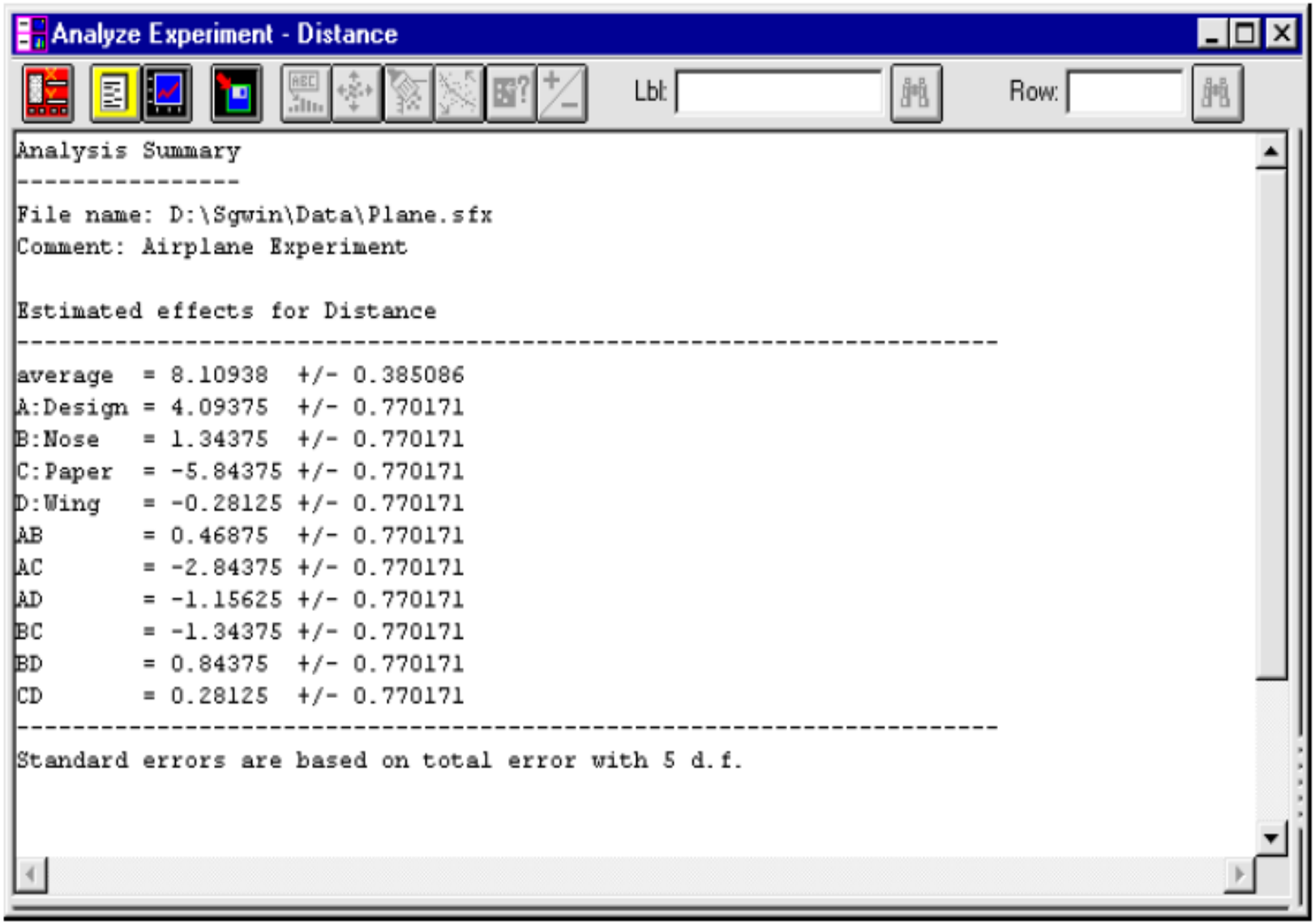

Figure 1-11. The Analysis Summary for the Airplane Experiment Design

Because you chose a full factorial design and collected 16 runs, all the main and two-factor interaction effects are estimates. You can ignore interactions greater than order 2 because higher-order interactions are typically negligible. To determine which factors contribute significantly to the flight distance, display the Pareto Chart.

3. Minimize the Analysis Summary and maximize the Pareto Chart (see Figure 1-12).

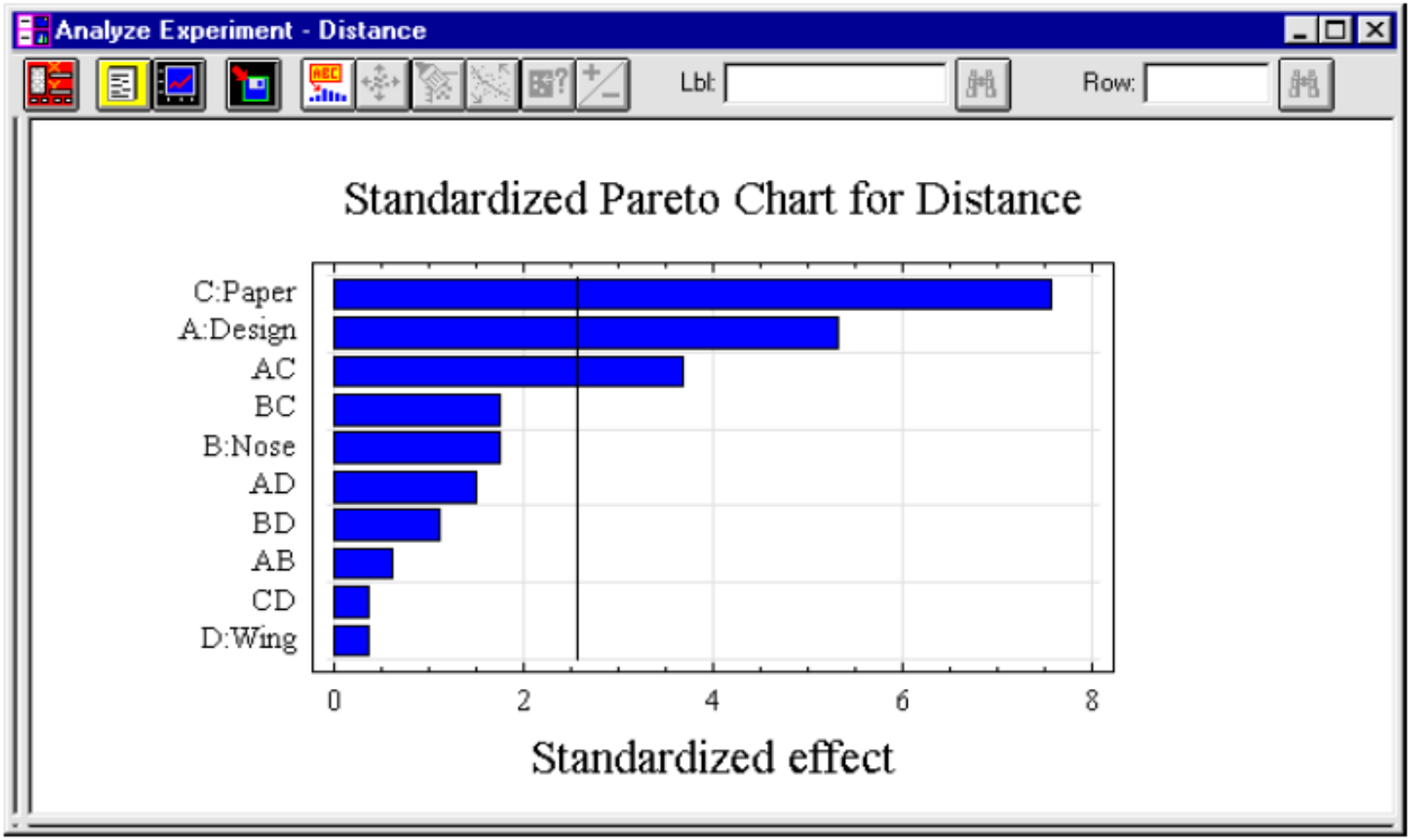

Figure 1-12. Standardized Pareto Chart

The chart shows that Paper (C), Design (A), and the AC interaction are significant effects because they cross the vertical line that represents the 95 percent test for significance.

The Main Effects and Normal Probability Plots of Effects could also substantiate these findings.

4. Click the Graphical Options button to display the dialog box, then click the Main Effects Plots, Interaction Plots, and Normal Probability Plots of Effects check boxes.

5. Click OK to display the plots in the second, third, and fourth graphics panes of the Analysis window.

6. Maximize the Normal Probability Plot of Effects (the fourth graphics pane).

7. Click the right mouse button on the plot, then the left on Pane Options to display the Effects Normal Probability Plot Options dialog box.

8. Choose the Half-Normal Plot, accept the defaults, Vertical, in the Direction section and Fitted Line, then click Label Effects. The dialog box should look like the one shown in Figure 1-13.

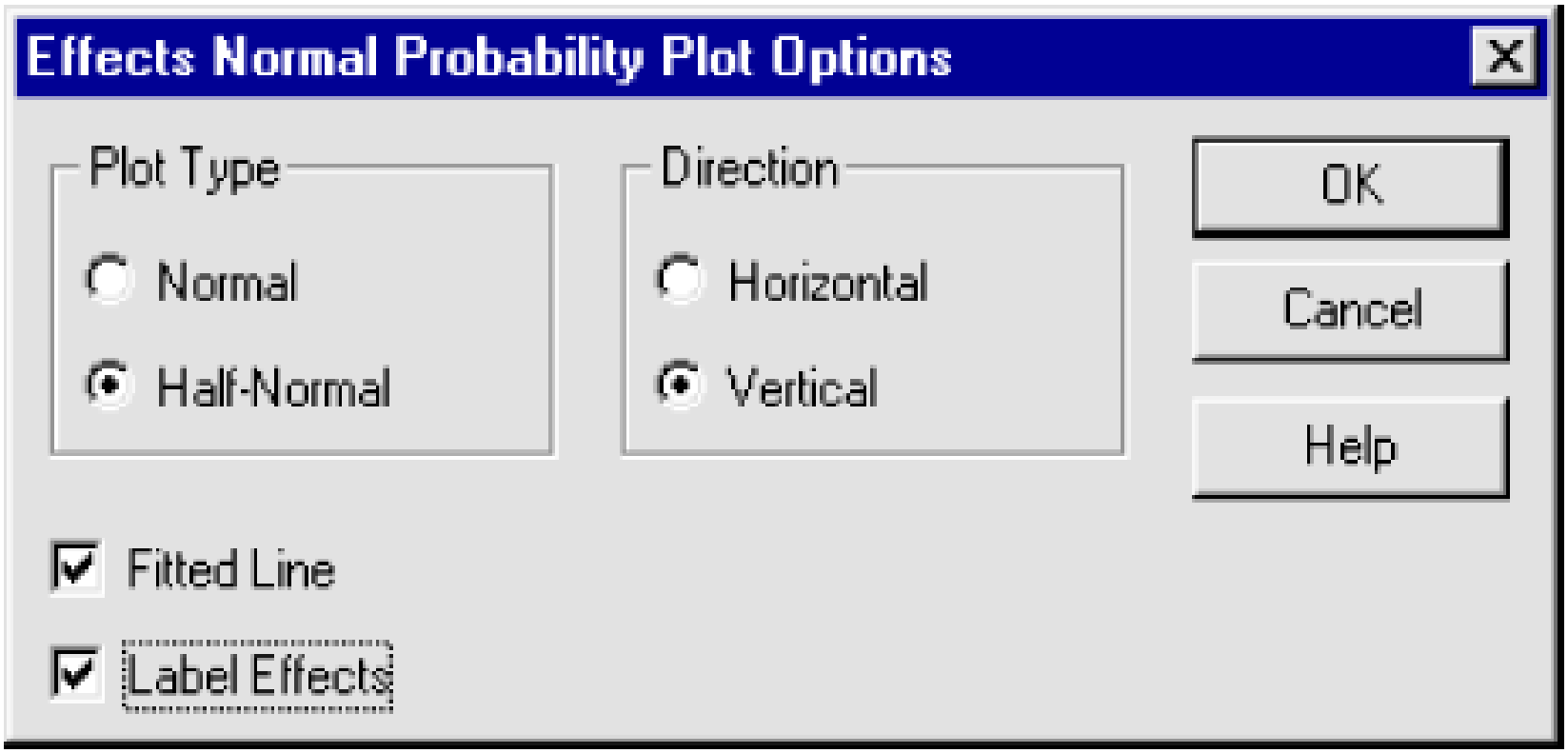

Figure 1-13. Completed Options Dialog Box

9. Click OK to display the Half-Normal Plot (see Figure 1-14).

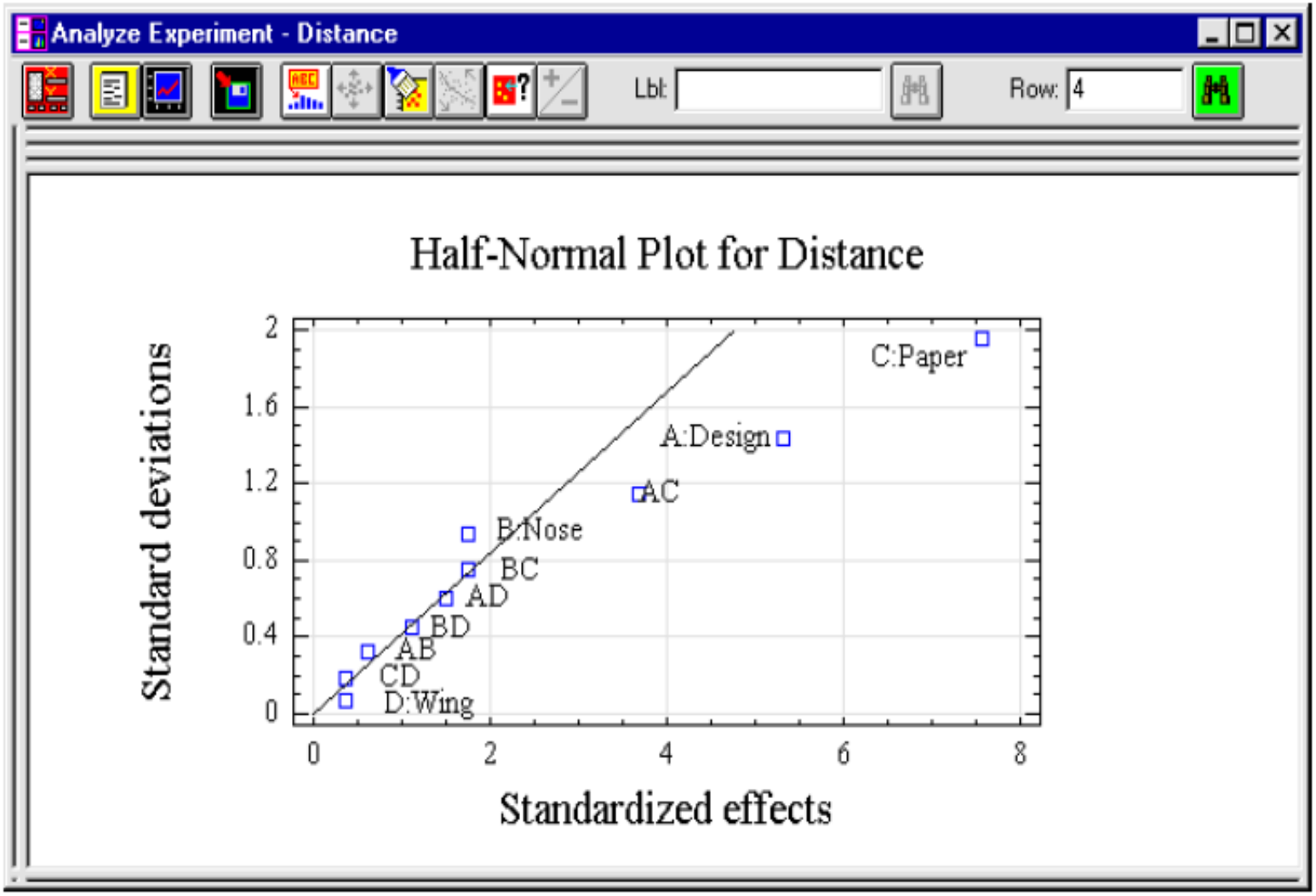

Figure 1-14. Half-Normal Plot

10. Minimize the Half-Normal Plot, and maximize the Interaction Plot (the third graphics pane).

11. Click the right mouse button on the plot, then the left on Pane Options to display the Interaction Plot Options dialog box.

12. Click the Design and Paper check boxes, then deselect Nose and Wing so the dialog box looks like that shown in Figure 1-15.

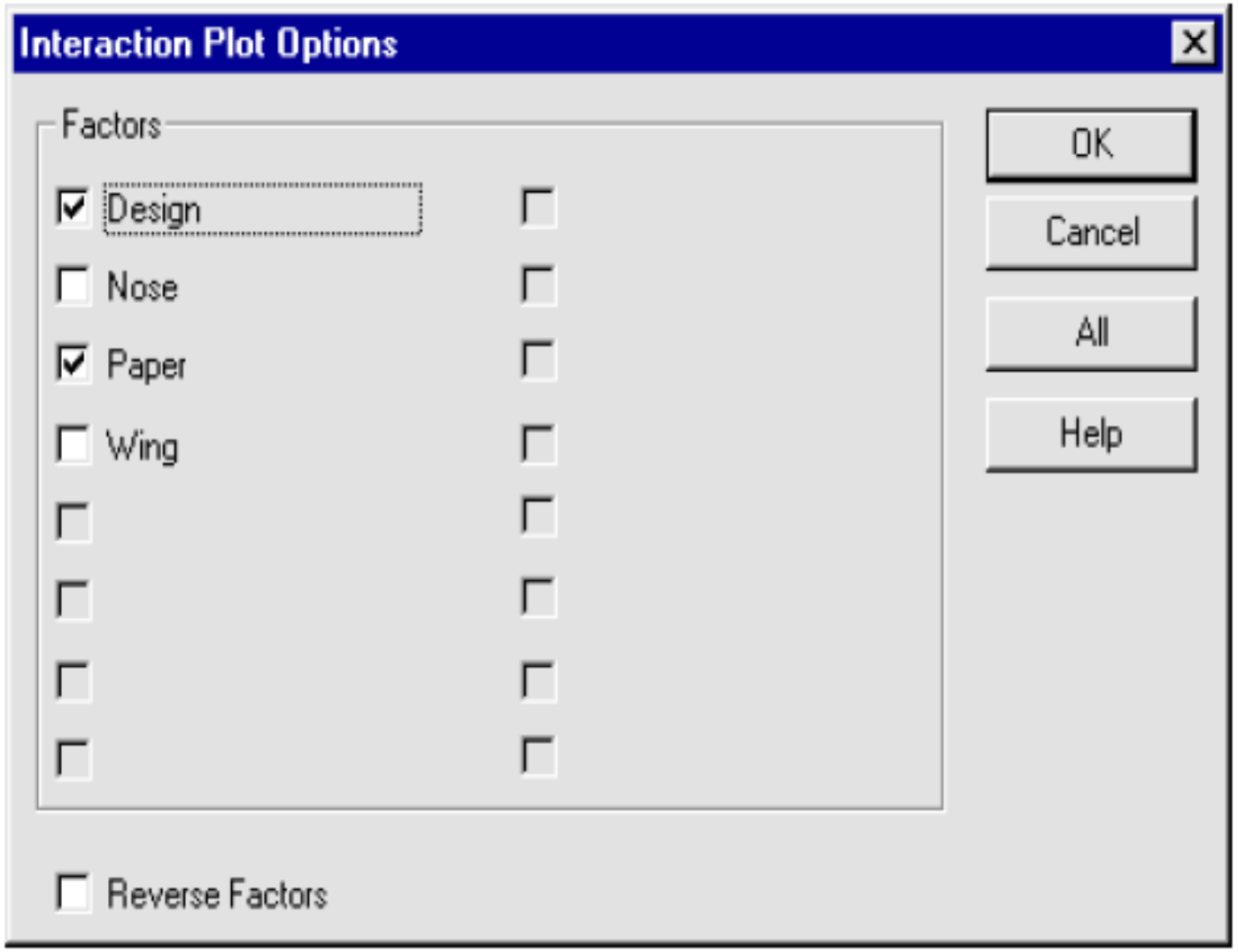

Figure 1-15. Completed Interaction Plot Options Dialog Box

13. Click OK to redisplay the Interaction Plot (see Figure 1-16).

The Interaction Plot shows that the distance is longer for the tee-shaped planes made from notebook paper. An analysis of variance (ANOVA) should also verify these findings.

14. Click the Tabular Options button to display the dialog box, then click the ANOVA Table option, and click OK to display the table. Maximize the table (see Figure 1-17).

The ANOVA Table shows that Factors A, C, and the interaction, AC are statistically significant (p-value < .05). Factors B and D and all the interactions among these factors are negligible.

Based on these findings, it seems that the type of wing and the paper type most significantly influence flight distance. The Main Effects and Interaction Plots show that tee-shaped planes made of notebook paper result in longer flight distances.

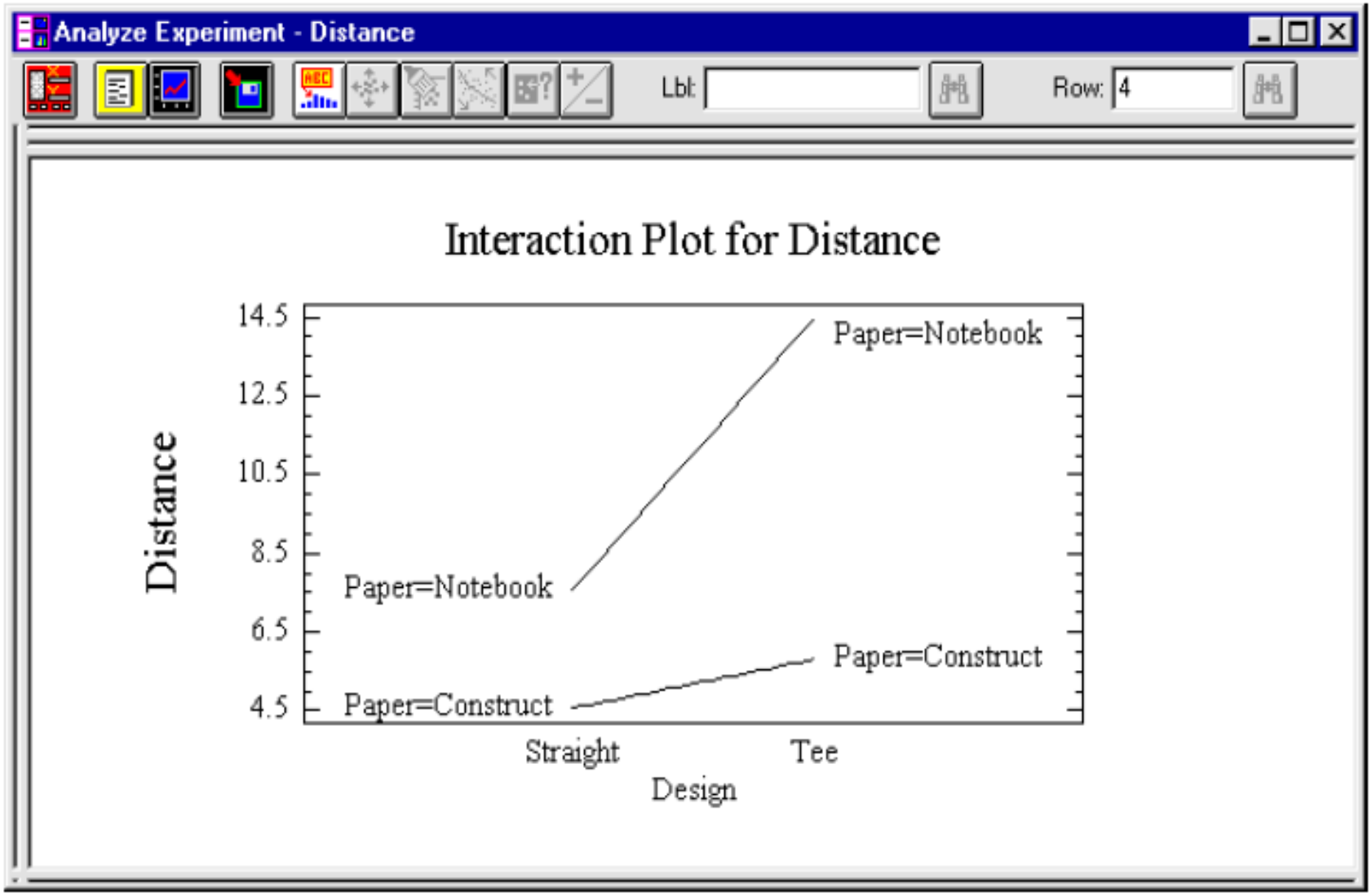

Figure 1-16. The Interaction Plot for the Airplane Distance Experiment

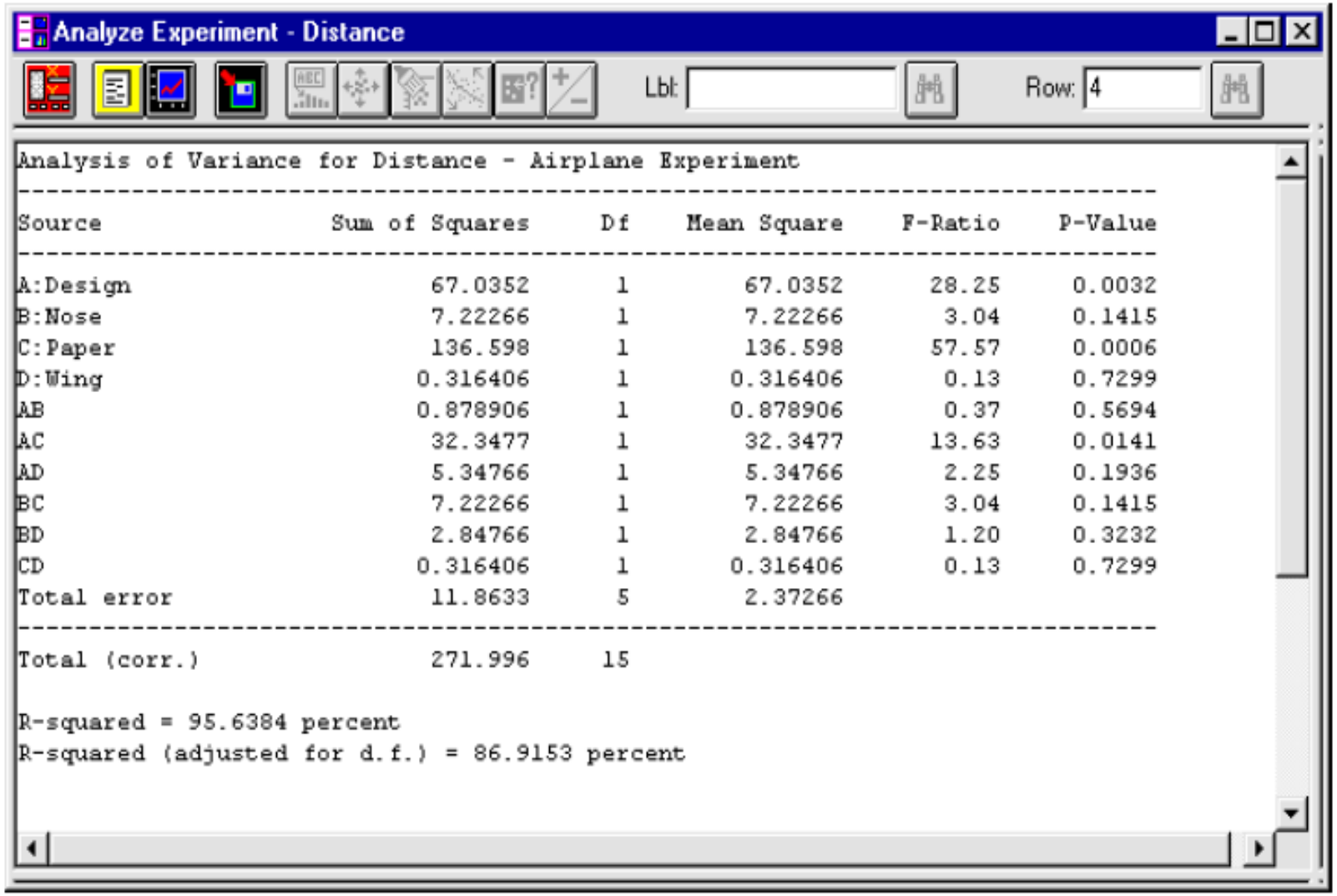

Figure 1-17. The ANOVA Table