

stat teaser

Workshop Schedule

DOE Simplified

November 20: Minneapolis, MN

An overview of Design of Experiments (DOE) from A to Z, based on the popular book. \$295*

Statistics for Technical Professionals

June 24–25: Minneapolis, MN

October 7–8: Minneapolis, MN

Revitalize the statistical skills you need to stay competitive. \$995*

Experiment Design Made Easy

August 5–7: San Jose, CA

September 9–11: Philadelphia, PA

October 21–23: Minneapolis, MN

November 18–20: Anaheim, CA

Study the practical aspects of DOE. Learn about simple, but powerful, two-level factorial designs. \$1495*

Response Surface Methods for Process Optimization

July 29–31: Minneapolis, MN

October 28–30: Minneapolis, MN

Maximize profitability by discovering optimal process settings. \$1495*

Mixture Design for Optimal Formulations

August 19–21: Minneapolis, MN

November 11–13: Minneapolis, MN

Find the ideal recipes for your mixtures with high-powered statistical tools. \$1495*

Robust Design: DOE Tools for Reducing Variation

September 16–18: Minneapolis, MN

Use DOE to create products and processes robust to varying conditions. A must for Six Sigma. *Factorial and RSM proficiency are required.* \$1495*

PreDOE: Basic Statistics for Experimenters

6-hour web-based training. This course or equivalent is a prerequisite for all workshops—www.stateease.net. \$95

Receive big discounts on public workshops when registering 3 or more students. Attendance is limited to 20. Contact Sherry at 800.801.7191 x18 or sherry@stateease.com.

*Includes a \$95 student materials charge which is subject to state and local taxes.



ABOUT STAT-EASE SOFTWARE, TRAINING, AND CONSULTING FOR DOE
Phone 612.378.9449 Fax 612.378.2152 E-mail info@stateease.com Web Site www.stateease.com

Messing With Medieval Missile Machines (Part 1)

"For a man's house is his castle." Sir Edward Coke (defender of common law against 17th century royal prerogatives espoused by King James of England).

This past winter I taught "Experiment Design Made Easy" to students and faculty at the South Dakota School of Mines and Technology (SDSM&T) in Rapid City. When I found out that they made scale-model trebuchets for experimentation by engineering students, I immediately asked for one in trade for a license to Design-Expert® software.

The SDSM&T trebuchet adds to a Stat-Ease arsenal that includes a scale-model catapult. For those of you not "into" medieval missile-hurling machinery, the catapult operates on tension or torsion, (a heavy rubber-band is used for the scale model); whereas a trebuchet uses a counterweight as its energy source.

I've just started my range-finding exercises on the SDSM&T trebuchet, so you



Siege Engines Built at the Medieval Center, Denmark
(photo courtesy of Dr. Peter Hansen, Denmark)



will have to wait a while for my technical report on it. Aside from being a "heads-up" on work-in-progress, this article provides details on a related experiment I performed on a trebuchet simulator.*

Credit for the trebuchet simulator goes to Bill Hathaway of MoreSteam.com, an Internet provider of Six Sigma training. Bill and his programmer really went all out to make their trebuchet realistic. They even put in a castle that can be knocked down with very satisfying sound effects.

To familiarize myself with the MoreSteam.com trebuchet I conducted pre-trials to literally do some "range-finding." My motto is: Ready, Fire, Aim! In this case, I got lucky and hit the castle after only a few shots, but that did not stop me: I designed some experiments to quantify the effects of the 7 controls on the simulated trebuchet:

- A. Boulder material: Limestone vs Granite
- B. Boulder weight: Light vs Heavy
- C. Sling material: Rawhide vs Rope
- D. Sling length: Short vs Long

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- E. Counterweight: Light vs Heavy
- F. Release prong: High vs Low
- G. Time of day: Night vs Day (lighting actually changes in the simulator background!)

The response was measured in meters off the mark (targeting the castle), which ideally would be zero—a devastating blow!

I employed my favorite two-phase strategy for "black-box" processes like this:

1. Do a 16-run Resolution IV screening design to reveal the key factors
2. If two-factor interactions (2fi's) emerge, follow up by doing an 8-run semifold (see page 3).

As you can see from the half-normal plot of effects in Figure 1, on the left, Bill did put some interactions into the MoreSteam.com trebuchet simulation. I used Design-Ease® software because this is what Bill recommends to his students for the level of DOE that they get into as part of their Six Sigma training.

Every 2fi is aliased with two other 2fi's in this 1/8th fraction (2^{7-3}). What most concerned me was:

- [AE] = AE + BG + DF
- [AF] = AF + BG + DE
- [BD] = BD + CF + EG

(Not shown above are four 4fi's and one 6fi also aliased with each of the interactions. They can be safely ignored due to physical improbability.) The 2fi's shown in bold indicate my guesses on the real effects. All the other 2fi's involve at least 1 factor that does not appear as a main effect (A, C, and G are shown crossed out).

Now I was ready to invest more effort into figuring out what made the MoreSteam.com trebuchet work. It was time for Phase 2—the semifold. This method requires choosing a single factor that is set at opposite levels in a second block of runs during which all other factors stay at their original pattern of levels. Half

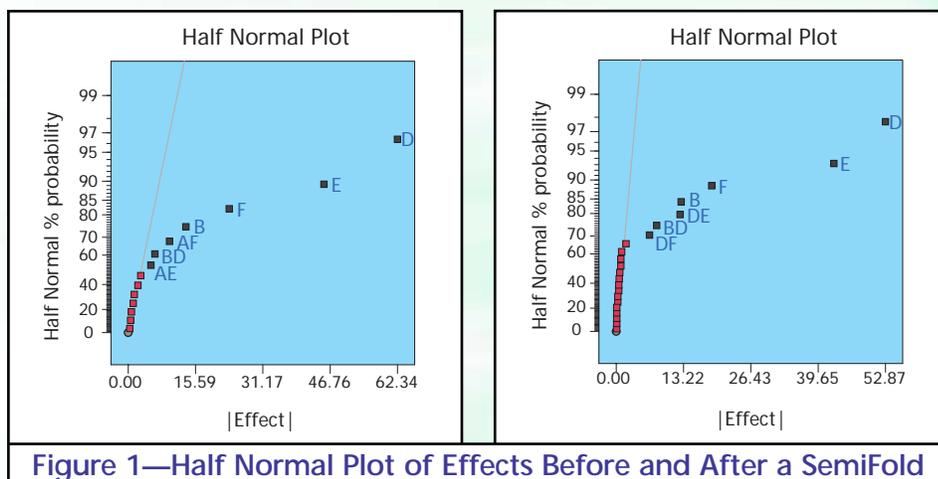


Figure 1—Half Normal Plot of Effects Before and After a SemiFold

of these runs are then discarded according to procedures detailed in the article on page 3. Once you know the rules it's not that difficult to set up this design augmentation, but to be safe, always assess the impact on aliasing. In this case the design evaluation revealed that I had succeeded in de-aliasing the problematic 2fi's by doing only the 8 additional runs (interactions involving 4 or more factors are not shown):

- [BD] = BD + CDF + DEG
- [DE] = DE + ADF + BDG
- [DF] = DF + ADE + BCD

I ran the additional combinations of factors, entered the responses (distance off-target in meters) and produced the plot of effects shown in Figure 1 above, on the right.

I guessed right! (Memo to Bill - you need to be more devious in developing your simulations!) At this stage Design-Ease (DE) falls a bit short of the mark compared to Design-Expert (DX) software, which provides optimization features for hitting a target. I opened the DE file with DX and entered zero plus-or-minus ten as the target—not bad for the typical simulated trebuchet toss of 100 meters. I also asked for the maximum boulder weight to wreak heaviest havoc on the castle (am I evil, or what?).

With the aid of the numerical optimization feature in DX, I found the ideal setup for the trebuchet. The heavy boulders fall within a meter of ground zero when com-

bined with the longer sling, bigger counterweight and release prong set low. Woe to the enemy hiding in their castle! If I were them, I'd surrender immediately!

Now I am ready to start working on the real trebuchet I got from SDSM&T. I have an ulterior motive. It turns out that my next-door neighbors operate a hot-tub in the back yard behind their one-story house. Throughout the year, even in the dead of winter, they soak out there with a television blaring until the wee hours of the morning. My thought (evil!) is to do a series of DOE's with the SDSM&T trebuchet using a racquetball, which happens to be about the size of an egg. My goal will be to consistently hit a target about the size of a hot tub with a flight that goes approximately the height and width of a one-story house (just kidding...maybe).

—Mark (mark@statease.com)

To be continued! In future installments I plan to reveal my partner Pat Whitcomb's approach to experimentation on the MoreSteam.com trebuchet simulator, which involved application of a new type of screening design offering minimum runs for maximum resolution. Just when I think I've learned all the tricks, Pat comes up with a new one! Don't worry, you will also be hearing from me on what happens with the real, not simulated, tre-

—Continued on page 3.

Semifolding—More Information, Fewer Runs

Resolution IV designs (color-coded yellow in the Design-Expert and Design-Ease factorial matrix) are recommended for screening. These designs will clearly identify main effects and let you know if any interactions exist. However, if there are interactions, they will be aliased with each other. Often it is difficult to guess the correct ones. (We don't all get as lucky as Mark!)

Traditionally, the foldover technique has been used for design augmentation of fractional factorial designs. For Resolution IV designs, it is recommended that you use a single-factor foldover. This technique creates a second block of experimental runs where one factor is set at opposite levels from the original runs and all other factor levels stay the same. The analysis of the combined design then allows you to estimate, in addition to the main effects, all of the two-factor interactions that involve the factor that was folded on.

The price for this additional information is double the runs. For example, if the original design was 16 runs, you have to complete an additional 16 runs. Often this involves a lot of extra work just to find out which of two or three interactions is the real one.

A semifoldover, on the other hand, is started just like a foldover, but only half of the runs are completed. If the original design was 16 runs, a semifold would require another 8 runs. This is

generally sufficient to de-alias the interactions of interest and saves a great deal of time and money!

Here's a general outline of the procedure. If you want more details, see the article posted on our web site (referenced at the end of this article).

Start with a Resolution IV design that has clearly identified some main effects and shows that there are some interactions present.

1. From the Design Layout screen, choose **Design Tools, Augment Design**. Select the **Foldover** option.
2. Pick one of the factors that is involved in the interaction you want to de-alias. For instance, if the AB interaction was identified, you could choose either A or B. Delete the check marks by all of the other factors except, say, A.
3. Click **OK**. At this point you get a box asking if you want to view the Design Evaluation. This is generally a good idea, but since you're not done making modifications yet, choose No. You'll do this later.
4. The foldover runs are created, but you want only half of them. Sort by a factor that was NOT statistically significant in the original analysis. Then, sort on the Block column.
5. For the non-significant factor, decide which level you would rather run (maybe the standard, or the cheapest.) Then DELETE the runs that are at the level you don't want. (Since you sorted according to these instructions,

these runs should be in a group.)

You are now left with half of the foldover, or a semifold. At this point you should go to **Design Evaluation** and double-check the new alias structure to make sure you will get the information you want.

Now that you have learned something about the technique Mark used for his trebuchet experiments, try it out for yourself. For more details and examples, see the article, "Save Runs, Yet Reveal Important Interactions by Doing a Semifoldover," posted at <http://www.statease.com/articles.html>.

Look for more about foldover and semifold techniques in the May issue of Quality Progress magazine. See the article, "Augmented Ruggedness Testing to Prevent Failures," by Mark Anderson.

—Shari (shari@statease.com)

Where can you find us?

August 3-7 — Joint Statistical Meetings, San Francisco, CA Booth 205.

Roundtable Discussion by Shari Kraber:

"Altering Central Composite Designs"

October 16-17 — Fall Technical Conference, El Paso, TX.

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buchet I got from SDSM&T.

* (Note from pg. 1) Stat-Ease "DOE FAQ Alert," Volume 2, Number 1, January 2002, Item #3. "Simulation Alert: Try your hand at knocking down a castle". Past issues, and

instructions on how to subscribe to this monthly informational e-mail, can be found at www.statease.com/doesalert.html. However, you may find that some of the old links no longer work.

Bill has posted the trebuchet simulator

again for a limited time in connection with this article. Have some fun and experiment with it yourself! You will find the simulator at: www.moresteam.com/trebuchet_se.cfm. My data for this article is available at: www.statease.com/misc_data/trebuchet.dxf.

PreDOE—Basic Stats Course

Stat-Ease recently launched a new statistical education web site at www.statease.net. Currently, this site features two opportunities for students.

Statistics Self-Assessment

People who are interested in taking Stat-Ease's "Experiment Design Made Easy" workshop, but who are not certain they have the necessary statistical skills, are encouraged to complete a FREE online self-assessment questionnaire. This questionnaire will help you determine whether or not you are adequately prepared for a DOE workshop and are comfortable with the materials. If not, you can take the PreDOE online course for only \$95.00.

PreDOE—Basic Statistics (\$95)

People who would like a review of basic statistical concepts are encouraged to participate in this self-paced, interactive online course. The content will take 3-6 hours to complete, depending on your

current familiarity with the material. Upon successful completion of the course (which means passing the test with a score of 80% or greater) students will receive a certificate with 0.6 CEU's.

How Do You Start?

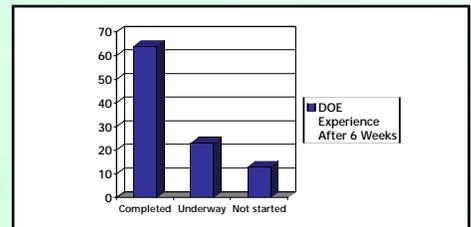
Log on to www.statease.net and click on the "New Student" button. On the next screen, select either the "Statistics Self Assessment" or "PreDOE—Basic Statistics" course option. You may also view a syllabus for either course here. On the next screen, enter your name, address, and e-mail information. Instant access is provided for the free "Statistics Self-Assessment" questionnaire. For the "PreDOE" course, you will be sent to a secure site to provide credit card information. If you wish to pay by purchase order, simply give us a call and we will process your registration manually. Questions? Please e-mail shari@statease.com.

How Do We Rate?

6/03

At Stat-Ease we strive to offer workshops that are fun, comprehensive, relevant, and understandable. Classes range from introductory DOE and statistics, to advanced workshops for the experienced experimenter. To provide high-quality courses that best fit our students needs, we ask for feedback during and after workshops.

The response we get is overwhelmingly positive with 95% of students rating their workshop 4 or above on a scale of 1-5 (5 = highest), with an overall workshop rating of 4.3. 87% of Stat-Ease students have either completed or are working on a DOE 6 weeks after their class ends. To find out more about Stat-Ease workshops, go to www.statease.com.



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Stat-Ease, Inc., Hennepin Square
Suite 480, 2021 E. Hennepin Ave.
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