

## Design of Experiments (DOE) Using JMP®

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### ABSTRACT

JMP® has provided some of the best design of experiment software for years. The JMP team continues the tradition of providing state-of-the-art DOE support. In addition to the full range of classical and modern design of experiment approaches, JMP provides a template for Custom Design for specific requirements. The other choices include: Screening Design; Response Surface Design; Choice Design; Accelerated Life Test Design; Nonlinear Design; Space Filling Design; Full Factorial Design; Taguchi Arrays; Mixture Design; and Augmented Design. Sample size and power plots are available. We give an introduction to these methods followed by examples with factors.

### INTRODUCTION

With the advent of computer science in the 1960s, many aspects of experimentation were enhanced, from tracking planning, recording quality control of manufacturing, fitting data, and even running advanced computer models to precede manufacturing experiments. The science is not limited to manufacturing but goes to IT, information technology, survey technology, and management. Early design of experiments improved crop yield in agriculture—many disciplines could benefit from the science of design of experiments.

### PRESENTING THE PLATFORMS — JMP/DOE EXPERIMENTAL DESIGN



#### Full Factorial Design

The basis of the science is to choose ranges for the  $n$  factors and assign a top value and low value for each factor. The factors can be varied and optimum results calculated. The icon picture represents an  $n$ -dimensional cube and if a middle dot is shown, it means a middle value can also be used.



#### Screening Design

By cutting down, in a patterned manner, the number of experiments to conduct, the most important and dominant factors can be found first.



#### Response Surface Design

At this point, you may want to do some auxiliary statistical graphics, visualization, and optimization exploration. You can do this with JMP to look for local and global maximum or minimum points on the factor surface.



#### Custom Design

The JMP Custom Design allows you to tailor your plan of experiments to meet specific requirements. You may want to arrive at Custom Design after approaching with other design options, if the cost is not prohibitive. **Design professionals begin with Custom Design.**



#### Mixture Design

For the product, survey, or other model such as the US National Budget where factors add up to a fixed sum, you may choose to investigate options with the Mixture Design. You are not limited to three 'ingredients' in the 'recipe' but can apply as many as you choose to include.



#### Choice Design

The term 'choice' does not mean it is the most choice, but rather included factors are by choice. At some point, your customer (who may be your boss) may want to specify the factors; or attributes of interest in the case of surveys.

# The Twelve Areas of JMP Design of Experiments

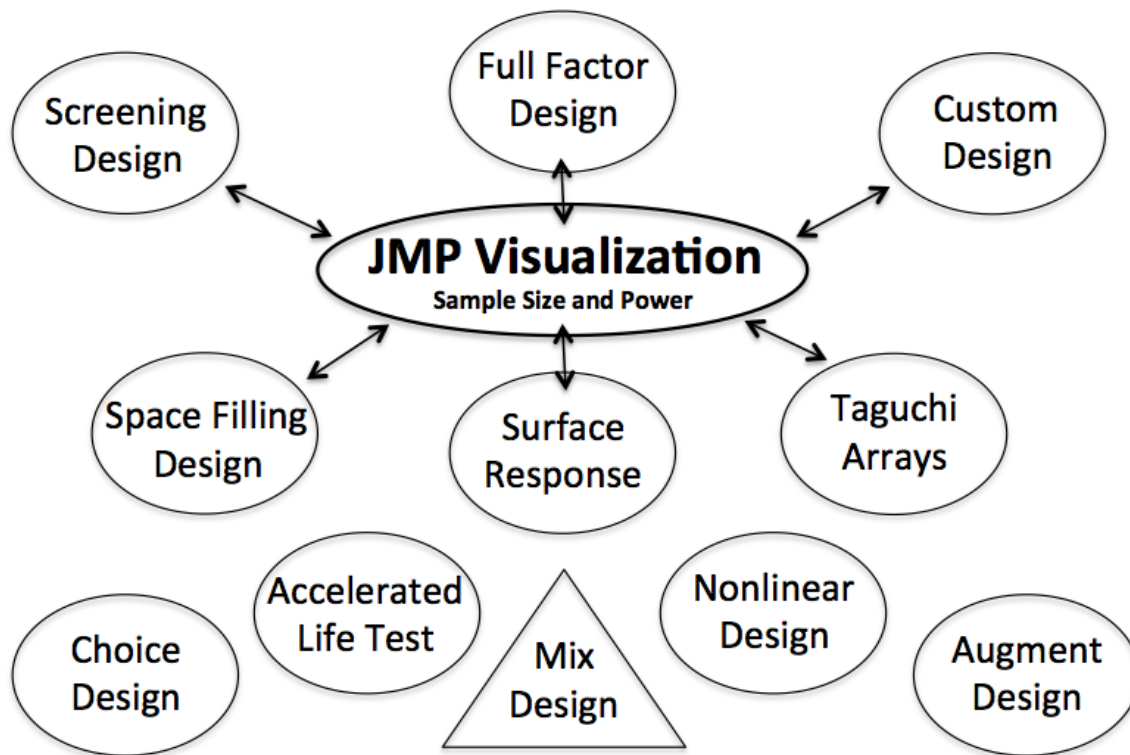


Figure 1

Referring to Figure 1, you can start with a screening design, a full factor design, a custom design, or some other approach such as a choice design (selecting factors specified by the customer) and end up with a final planned design—for example the custom design or the augment design. Start anywhere, end anywhere. The nature of discovery by design of experiments is that it is iterative.



## Space Filling Design

To quote from the DOE Guide, “Space-filling designs are useful for modeling systems that are deterministic or near-deterministic. One example of a deterministic system is a computer simulation. Such simulations can be very complex involving many variables with complicated interrelationships. A goal of designed experiments on these systems is to find a simpler empirical model that adequately predicts the behavior of the system over limited ranges of the factors.”



## Accelerated Life Test Design

To quote from the DOE Guide, “Often in reliability studies, the product reliability at use conditions is so high that the time required to test the product until it fails is prohibitive. As an alternative, you can test the product in conditions that are more extreme than normal use conditions. The extreme conditions enable the product to degrade and fail sooner, making a reliability study possible. Results are used to predict product reliability at normal use conditions.”



## Nonlinear Design

You can begin here if you want. Create the optimal design for models that are nonlinear in the parameters.



## Taguchi Arrays

Make inner and outer arrays from signal and noise factors. This is classic. There are two versions of the Taguchi methodologies, modern replaced classical.



### **Augment Design**

Add more runs to an existing data table. Replicate, add center points or intermediate measurement points, fold over, or add model terms.



### **Sample Size and Power**

Plot any two of the power to detect an effect, the sample size, and the effect size given the third. Or compute one given the other two.



### **Evaluate Design**

Show the confidence level evaluation and the design diagnostics whether the plan is an optimum design or not.

## **SUMMARY AND CONCLUSION**

JMP is superior to other tools because of its Custom Design platform that guides you through DOE. The power of JMP design of experiments gives you a competitive edge of superior products/services developed more economically. Companies and agencies trust the power of SAS Institute and JMP. In showing the 12 areas of JMP design of experiments, we cover examples for manufacturing, sales, and IT information technology simulation. Evaluation of optimum design is possible with Evaluate Design.

## **ACKNOWLEDGMENTS**

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## **RECOMMENDED READING**

Peter Goos and Bradley Jones, **Optimal Design of Experiments: A Case Study Approach**. 2012, SAS Press; (also available via Amazon.)

## **CONTACT INFORMATION**

Comments and questions are valued, encouraged, and rated. Contact the author at:

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