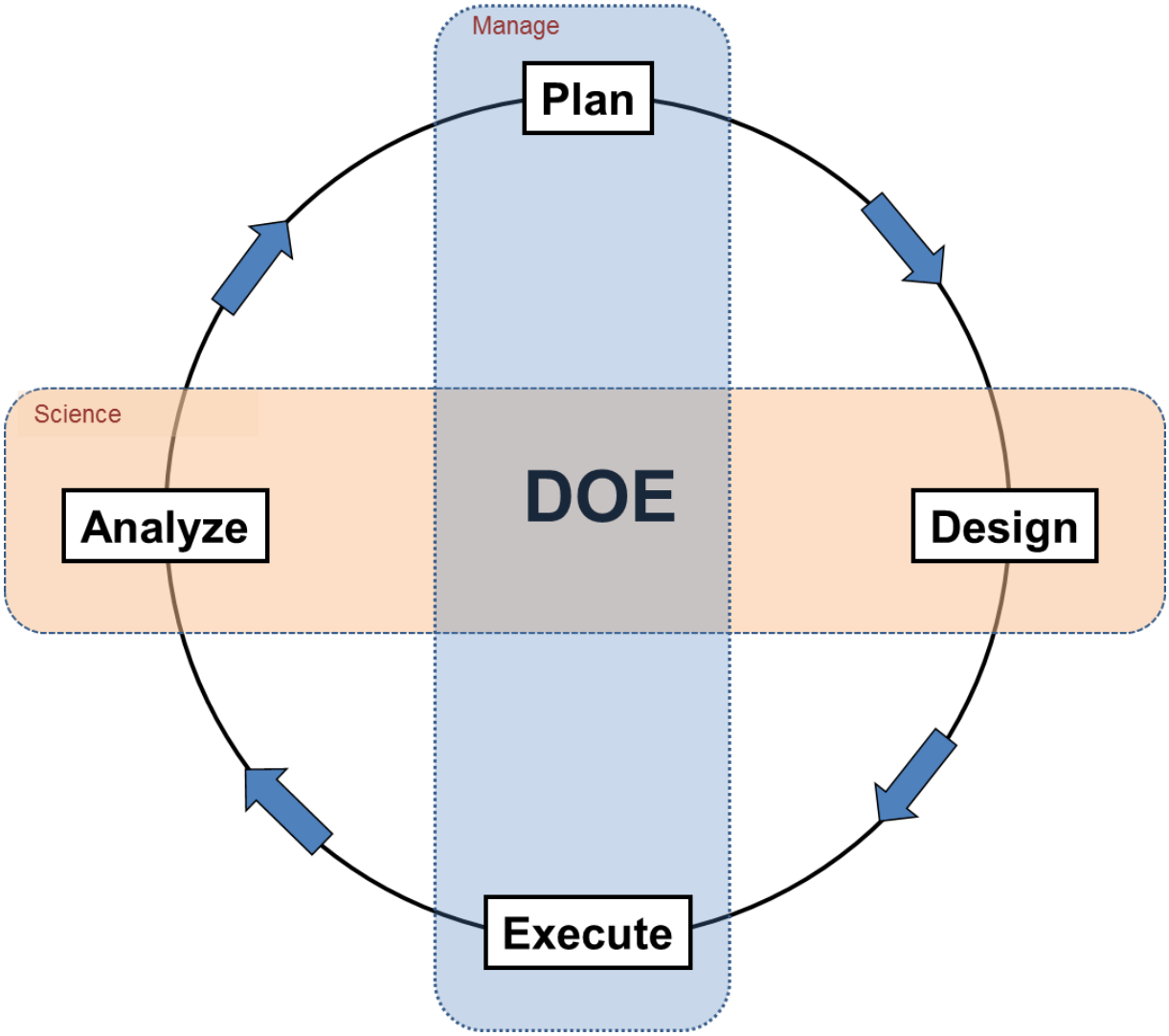
Short Courses in Applied Statistics and the Design of Experiments (DOE)



Jim Simpson, JK Analytics , LLC

Applied Statistics and DOE Courses Overview

Course Title	Duration	Target Audience
Design of Experiments (DOE) Executive Overview	1 – 2 hours	Senior Executives and Leaders
DOE for Leaders	4 hours	Mid-level Managers and Supervisors
DOE Essentials: Introduction to Experimental Design	2 days	Test and Project Engineers, Project Managers, Test Directors
Basic Statistics for Test	2 days	Test Engineers, Project Engineers, Managers, Test Directors, Scientists
Statistical Analysis Methods	2-3 days	DOE Practitioners, Operations or Test Analysts, Test Engineers, Project Engineers, Scientists, Statisticians
Regression Analysis in R	3-4 days	Test Engineers, Operations or Test Analysts, Acquisition or Project Engineers, Scientists, DOE Practitioners, Statisticians
Repeated Measures Design and Analysis	2 days	DOE Practitioners, Operations or Test Analysts, Test Engineers, Project Engineers, Scientists, Statisticians
Statistical Methods for M&S Verification and Validation	3 days	DOE Practitioners, Operations or Test Analysts, Test Engineers, Project Engineers, Scientists, Statisticians
DOE 1: Experimental Design and Analysis - Foundations	4 days	DOE Practitioners, Acquisition or Test Engineers and Scientists, Program and Project Managers, Operations or Test Analysts
DOE 2: Experimental Design and Analysis - Characterization	4 days	DOE Practitioners, Operations or Test Analysts, Test Engineers, Project Engineers, Scientists, Statisticians
DOE 3: Experimental Design and Analysis - Response Surfaces	4 days	Experienced DOE Practitioners, Operations Analysts, Test Engineers, Project Engineers, Scientists, Statisticians
DOE 4: Experimental Design and Analysis – Advanced Topics	4 days	Experienced DOE Practitioners, Statisticians, Experienced Operations Analysts
Split-Plot Design and Analysis	1 day	Experienced DOE Practitioners, Operations Analysts, Test Engineers, Project Engineers, Scientists, Statisticians
Statistical Power Analysis	½ - 1 day	DOE Practitioners, Acquisition or Test Engineers and Scientists, Program and Project Managers, Operations or Test Analysts
Probability and Statistics for Reliability and Reliability Growth	4 days	Reliability engineering practitioners, RAM engineers, project managers, statisticians, test engineers, suitability engineers

Cost: $2750/day + travel expense

Design of Experiments (DOE) Executive Overview

Target audience:	Senior leader audiences; or general acquisition, science, and engineering individuals wanting an introductory overview of the design of experiments (DOE)
Pre-requisite:	None
Duration:	1-2 hours
Description:	This introductory course demonstrates a powerful methodology for test and evaluation: design of experiments (DOE). The case for DOE begins with a presentation of the central challenge of test – how to draw enough samples to make the correct fielding decision, while simultaneously testing across a broad test space. DOE answers four fundamental questions: how many trials, under what conditions, executed in what order, and what are defensible conclusions? DOE history is discussed along with a series of case studies to illustrate how it works. The course features test examples showing how DOE often reduces testing cost by 30-80% while increasing knowledge; conversely the course discusses several cases where tests had too few assets and should have been augmented. The concluding portion of the course addresses challenges of leading change that must be dealt with to successfully alter the way an organization typically conducts tests.
Objectives:	People who complete this training will: • Understand the central challenge of test and the basic DOE process • Understand leadership's critical role in deploying the DOE concept throughout an organization • Understand the potential of implementing DOE to "right size" each test • Understand barriers which must be overcome to successfully conduct testing

DOE for Leaders

Target audience: Mid-level managers and supervisors

Prerequisite: None

Duration: 4 hours

Description: Various test organizations have been using design of experiments (DOE) as its principal method of test, with great success. Benefits include faster tests, fewer test resources, and greater system understanding all while increasing the confidence in test results. From digital simulation to engineering-oriented hardware-in-the loop, to production representative test, DOE 1s being applied to all types of test. This ½ day tutorial introduces attendees to statistically-based experimental design -- a powerful methodology for test and evaluation. We provide an executive overview, compare it to several alternative test strategies, and describe a four-step process to effectively plan, design, execute and analyze the results of tests of often complex systems involving many factors (system settings, system operation conditions, environment and system interface) and their potential impact on measures of performance, effectiveness, or suitability. Examples are provided throughout along with demonstrations of statistical software packages that enable both the design of the test matrices and the analyses of the test data. The concluding portion of the course addresses barriers to change that must be overcome to successfully change the way an organization typically conducts tests. The attendee will be able to appreciate simple factorial experiments with multiple variables, know what kinds of designs novices should prefer and know when to look for help. The course is geared toward leaders of technical organizations.

Objectives: People who complete this training will:

- Understand the central challenge of test and the basic DOE process phases
- Understand leadership's critical role in deploying the DOE concept throughout an organization
- Understand the key principles and procedures associated with planning, designing, executing, and analyzing a designed experiment
- Understand the benefits of implementing DOE to "right size" each test
- Understand the necessary steps to take to successfully implement the science of test as standard practice

DOE Essentials: Introduction to Experimental Design

Target audience: Project managers, test/project engineers, and test directors leading a team conducting a designed experiment. While graduates will not be practitioners of DOE, they will be conversant with unique features of DOE tests and will be able to facilitate discussions among practitioners and experts. Scientists and engineers wanting to explore whether DOE holds promise in their area of expertise will also benefit from this course. Other students who may profit include technical supervisors of R&D, test and evaluation, product qualification, and digital simulation.

Prerequisite: Some familiarity with how experiments or tests are usually conducted is helpful, but not required

Duration: 2 days

Description: This course surveys the science of test process to deal with more than one variable (e.g., pressure, velocity, direction, aspect, etc.) and their effects on performance. This practical introduction covers the general approach to testing using a statistically-based method for choosing the test set and an analysis method for objectively discovering the variables significantly influencing effectiveness. The course topics include an introduction to the science of test, hypothesis testing and sample size determination, constructing test matrices using factorial designs, and statistical model building. The graduate will be able to design and analyze simple factorial experiments with up to four variables, and know what methods are being employed by the test engineers and OA's. We use Excel and Design Expert and a course project is integrated throughout to enforce the methods presented.

Objectives: People who complete this training will:

- Appreciate the importance senior leadership has placed on applying DOE to the test environment, understand how DOE addresses the fundamental challenges of test, and know the steps involved in DOE by example
- Understand the importance of defining test objectives
- Understand basic statistics, how hypothesis testing is used, be able to build and analyze a hypothesis test, and know the importance of sample size, confidence and power
- Understand confounding, know the importance of randomization and blocking, generate and analyze factorial and fractional factorial designs, and know how to design for power
- Understand regression modeling, know how to interpret results of ANOVA and regression analysis, and know how this applies to analysis of designed experiments
- Understand the planning process after having been exposed to DOE. The student will understand how best to define the inputs and outputs of a test program, some metrics of alternative test designs, the impact execution has on planning, and how to apply sound planning principles to a real-world test example

Basic Statistics for Test

Target audience: Test analysts, DOE apprentices, junior operations analysts, test project engineers, test engineers, scientists, and managers.

Prerequisite: None, and serves as an excellent primer for the DOE course series

Duration: 2 days

Description: This course covers the fundamentals of probability and both descriptive and inferential statistics for those either interested in becoming familiar with the power and purpose of statistical methods and statistical thinking, or those desiring to review the foundational principles of statistical methods. Those attending this 2-day course will learn by seeing and practicing statistical analysis using the best statistical software available, JMP. Emphasis is placed on in-class exercises and student seatwork case studies covering exploratory data analysis, descriptive statistics, and the core inferential methods of statistical intervals, hypothesis testing, sample size determination and power analysis, and statistical empirical modeling.

Objectives: People who complete this training will:

- Understand the importance and relevance of probability and statistics in test and
    - Learn the statistics terminology and approach – effectively talk to your analyst/statistician
    - Know what information is needed to process data well
    - Determine which statistical methods are required to make specific test conclusions
- Understand principles of statistical analysis so that you can review analyses
    - Realize the importance and value of a statistically based test design
    - Discern the proper statistical techniques for analyzing data
- Reasonable expectations of this class are to:
    - Learn *basic* principles and skills for statistically-based design and analysis of test data, ready to f leading or participating in a designed experiment test
    - Understand the probabilities associated with incorrect conclusion and know the parameters affecting the calculations in right-sizing a test
    - What statistical “fingerprints” or metrics accompany a well-designed experiment

Statistical Analysis Methods

Target audience: Test analysts, DOE practitioners, operations analysts, test project engineers, test engineers, scientists, and statisticians. This course serves a supplement to the DOE series and provides more detail on data analyses.

Prerequisite: Some familiarity with how experiments or tests are usually conducted and how statistical analyses are performed

Duration: 2 - 3 days

Description: Parametric statistical analyses of test data provide an understanding of test outcomes and inform evaluations. In this course we will cover the steps involved in analyzing data from tests. The course will cover both the analytical methods and provide practical demonstrations using test data. Analysts who take this course will have a better understanding of appropriate analysis techniques for operational test data and how to use software to employ these analysis methods in their own data analyses. The course will begin with graphical methods of exploratory data analysis that should guide the analysis tools selected. A wide variety of statistical methods will be discussed, and often more than one method is appropriate for a given project. We use JMP as the primary software package and conduct demonstration exercises along with student exercises for each course topic. Nearly all example datasets are defense related.

Objectives: People who complete this training will:

- Comprehend the importance of statistical modeling the analyses of military test projects by studying over a dozen example cases in detail
- Know the details behind the methods for 2^k and fractional 2^{k-p} designs by review and in-depth study
- Use JMP software to perform exploratory data analysis, descriptive and inferential statistics, as well as parametric statistical modeling
- Know the best practices for exploratory data analysis
- Know the principles, methods, diagnostics, and shortcomings of ordinary least squares regression modeling
- Understand the methods for variable selection and model building assuming a linear regression model
- Know the procedures for validation, prediction and optimization
- Understand the pitfalls and remedial methods for unusual data to include outliers, skewed data, transformations and regression trees
- Know how to apply generalized linear models for binary and skewed data
- Understand the procedures for incorporating random effects and modeling data from a split-plot design

Regression Analysis in R

Target audience: Test Engineers, Operations or Test Analysts, Acquisition or Project Engineers, Scientists, DOE Practitioners, Statisticians. This course provides detail on data analyses using a freeware popular software package, R.

Prerequisite: None.

Duration: 3 - 4 days

Description: Regression analysis techniques applied to test data can provide superior knowledge and insights of test-driven weapon system performance so as to better inform program decisions. In this course we will provide students with the benefits of the use of statistical methods, the appropriate methods to employ for the given situations, and hands on analysis practices forming a regression analytic capability for post-test data analysis and reporting. The course will cover the basis and motivation for each of the analytical methods, provide practical demonstrations and allow for the students to then perform the analysis themselves. Graduates of this course will have a better understanding of appropriate analysis techniques for developmental and operational test data and how to execute the software to employ these analysis methods to their own data. The course will begin with an introduction to statistical software, followed by largely graphical methods for exploratory data analysis that can suggest appropriate analysis tools. A wide variety of regression-related methods will be covered, as often more than one method is appropriate for a given project and dataset.

Objectives: People who complete this training will be able to have skills with:

- Familiarization with R and RStudio software
- EDA and Data Visualization – descriptive, distributional, graphical
- Linear regression – benefits and cautions, compare/contrast analysis from DOE vs observational data, conclusions that can be drawn
- General linear models – for split plots and random effects
- Factor selection and model reduction techniques – NPP of effects, metrics to refine model
- Model validation –use of validation data
- Prediction based on statistical models - interval types and uses
- Methods for handling missing data, outliers, and skewed data
- Transformations of models – benefits and cautions
- Generalized linear models (including logistic regression) – ordinal, multinomial, Poisson, exponential
- Variable selection using partition trees or Classification and Regression Trees (CART)

Repeated Measures Design and Analysis

Target audience: Test analysts, DOE practitioners, operations analysts, test project engineers, test engineers, scientists, and statisticians. This course serves a supplement to the DOE series and provides more detail on repeated measures test design and analyses.

Prerequisite: DOE 1 or instructor consent

Duration: 2 days

Description: The course is intended to provide appreciation, understanding and the skills needed to plan, design and analyze the results of repeated measures studies. At the completion of the course, students will have the ability (1) to recognize when an experimental test strategy falls under the definition of a repeated measures (RM) design; (2) to optimally construct and properly calculate figures of merit for a RM design; and (3) to conduct proper, defensible analyses of the data from a RM design using common statistical software packages, e.g., JMP and R. The skills learned from this training will be implemented to support rigorous test and evaluation.

Lessons and Objectives: People who complete this training will:

Lesson	Objectives
Design Fundamentals for Repeated Measures	This module provides the fundamentals of DOE and observational studies and demonstrates how to apply these methods to repeated measures studies. Upon completion of this lesson, you will be able to: • Define and apply the fundamentals of DOE • Show how repeated measures are different and beneficial • Understand randomization, replication and blocking • Understand the 4 steps in the Plan and Design phases • Understand design options (classic experimental designs, optimal designs) • Understand statistical measures of merit (statistical model supported, power, confidence)
RM Design Choices and Considerations	This lesson focuses on test design alternatives once repeated measures has been deemed appropriate. Most test design methods are proven techniques in government and industrial applications • Single Replicate Disadvantages • Types of Repeated Measures Designs • Classical and Optimal • Design Adjustment from Classical and Optimal • Does Replication Make Sense? • Power Analysis • Relevance to Split-Plot Designs
RM Single Rep Design and Analysis – Dual Response	This lesson focuses on the analysis of a repeated measures design using a dual response approach (from robust design analysis methods). Power analysis of designs analyzed in this fashion is also demonstrated. • Single Replicate Benefits and Cautions • Measurement Error and Subject Variability • Design Adjustment from Classical and Optimal

	• Power Analysis • Dual Response Approach and Multiple Response Optimization • Analysis Thoughts
RM Subjects as Random Effects	This lesson focuses on analysis of executed repeated measures designs involving multiple subjects serving for repetitions. Subjects may or may not execute all treatment combinations. Sometimes the subjects are nested within a control factor. • Design and Analysis for Subject-to-Subject Variability • Modeling Subjects as Random Effects • Longitudinal Studies • Understanding and Comparing Alternative Models
RM Analysis of Binary and Count Data	This lesson focuses on analysis of repeated measures designs involving responses that are counts or binary outcomes • Generalized vs. General Linear Model • GLZ types and Examples • Add random effects from repeated measures • Generalized Linear Mixed Models for RM • Example

Statistical Methods for Modeling and Simulation Verification and Validation (M&S V&V)

Target audience: Test analysts, M&S analysts, operations analysts, test project engineers, test engineers, scientists, and statisticians. This course serves a supplement to the DOE series and provides more detail test design and analysis for validating models and simulations.

Prerequisite: DOE 1 or instructor consent

Duration: 3 days

Description: Statistical Methods for Modeling and Simulation Validation is a 3-day course in applied statistical methods for the planning, designing and analysis of simulation experiments and live test events for the purposes of verifying and validating models and simulations. The course emphasizes rigorous statistical design and analysis fundamentals of validation for modeling and simulation, briefly discussing current practices while spending the majority of the class time on recommended future practices. The first day starts with introducing the value of a statistical perspective, then offers a general strategy for assessing modeling and simulations. Current verification and validation policies are then covered, followed by a basic introduction to data visualization and the essentials of statistical methods. Day 2 kicks off with fundamentals for validation data collection using specific statistical test design and analysis techniques. Session 2 is methods for live testing design and analysis in support of M&S validation, and the last session that day provides methods for small run live vs. simulation comparisons. In-class exercises are worked throughout the day. Day 3 begins with methods to apply only to the M&S for system characterization and validation of intended uses for which no live data is available. Designs for both the simulation and the live testing realms include space-filling, optimal and split-plot designs, which are not only appropriate for live and M&S and ensure adequate statistical power to detect differences while sufficiently spanning the intended operational space. The final session covers large run live vs. simulation comparison. The final ½ day is a capstone project for students to practice their new skills on a real-world problem. We look forward to your participation in this course.

Objectives: Understand principles of statistical methods as they apply to the planning, designing and analysis of simulation experiments as well as live subsystem and system testing in order to verify and validate the models and the simulations. Reasonable expectations from this class:

- Know the process for successful statistically-based verification and validation of models and simulations
- Learn fundamental principles & skills to craft a statistically well-designed simulation or live test experiment
- Understand importance of test point placement in the operational space for the purposes of minimizing factor correlation, maximizing statistical confidence and power, while sufficiently covering the space
- Learn and experience implementing appropriate analysis techniques for exploratory data analysis, statistical modeling and statistical emulator generation, and methods for comparing live data to simulation results

DOE 1: Experimental Design and Analysis - Foundations

Target audience: Future DOE practitioners, acquisition or test engineers and scientists, technically oriented program or project managers, operations or test analysts, and others interested in the design, execution, and analysis of test programs. While graduates will not be fully capable DOE practitioners, they will have first-hand knowledge of all the essential elements of DOE, will have worked through a number of examples, and will have sufficient experience with, and a reasonable command of a DOE software program. This course also serves as the 1st week of the 3-week series for operations analysts and test engineers, and serves to survey the most important DOE concepts and tools. Scientists and engineers wanting to explore whether DOE holds promise in their area of expertise will also benefit from this course. Other students who may profit include technical supervisors of R&D, test and evaluation, product qualification, and digital simulation.

Prerequisite: A previous course in statistics is helpful, but not required.

Duration: 4 days

Description: This course not only serves as the first of three one-week courses for DOE practitioners, but also is designed as a stand-alone survey course in design of experiments. After an executive overview and a brief survey of statistical methods for applying the scientific method to test, the course introduces multifactor designs that vary multiple test conditions simultaneously while retaining the ability to link cause to effect. We explore test design options with factors at two or more levels, including strategies for running a fraction of all combinations, designs for nonlinear response spaces (response surface methods), and design augmentation schemes to resolve ambiguities in the test outcomes. Advanced approaches to experimental design including optimal designs and split plot designs are demonstrated. Throughout the course, the subsequent analysis and model-fitting properties of the contemplated designs will be explored. Just prior to the capstone laboratory exercise, other options in experimental design will be outlined, including the use of random effects factors and covariates. Students will become familiar with the powerful statistics program Design Expert (www.statease.com for free 45 day download). The course material is conveyed through the use of lecture, group discussion, student exercises, group laboratories, and electronic reading materials.

Objectives: People who complete this training will:

- Understand the need for statistics in test and evaluation
- Understand hypothesis testing, error types, and how to design defined-risk tests
- Understand the mechanics and benefits of two-level factorial designs
- Understand the efficiencies of and approach to testing using fractional factorial designs
- Be able to analyze factorial and response to surface designs
- Be able to develop response surface designs and understand reasons for selecting these designs
- Be able to plan, design, execute, and analyze a test using designed experiments
- Be familiar with special-use design options such as split plot and optimal designs

DOE 2: Experimental Design and Analysis - Characterization

Target audience: Rising DOE practitioners, operations analysts, test project engineers, test engineers, scientists, and statisticians. Graduates will be well on their way to completing all the academics required to take on the roles and responsibilities of a DOE practitioner. They will be conversant not only in the methods, but will have an appreciation for why certain methods are more advantageous in certain scenarios and they will be very capable interacting with DOE software for design and analysis needs. This course also serves as the 2nd week of the 3-week series for operations analysts and test engineers, and serves to reinforce and build upon the most important DOE concepts and tools.

Prerequisite: DOE 1 or instructor consent

Duration: 4 days

Description: This is the second of three courses in well-designed experiments and analysis techniques for maximizing knowledge while minimizing risks of incorrect conclusions. You will learn how to well plan, conduct and analyze experiments efficiently for effective use. This course strongly emphasizes two-level factorial and fractional factorial screening designs with tests for nonlinear behavior, augmentation, plus efficient factorials with any number of variables at any number of levels. The course series has a strong applied flavor and is intended to graduate practicing experimentalists. The course goal is that students learn to plan, design and conduct experiments for characterizing systems or processes, and analyze the resulting data to obtain objective conclusions. The techniques emphasized will be metrics of a well-designed experiment, the 2-level full factorial, fractional factorials, design augmentation, blocking, and the mixed-level fractional factorial with any number of variables at any number of levels. Computer software (Design Expert - www.statease.com for free 45 day download) will be used extensively, and you will grow comfortable in designing and analyzing tests on your own, including the week long course project.

Objectives: People who complete this training will:

- Use Design Expert to design, graph, analyze and report on data sets
- Use sound experimental or test techniques in planning, designing and executing experiments
- Have a solid grasp of the assumptions and methods of empirical modeling using least squares regression
- Design and analyze 2^k replicated full factorial, single replicate full and fractional factorial designs, as well as general factorial and mixed level fractional factorial designs
- Understand how to control for nuisance sources of variability with blocking
- Understand the capability of optimal designs to provide test matrix solutions for special needs conditions
- Know the importance and mechanics of sequential testing, including an initial screening experiment followed by augmentation to decouple model terms, estimate second order relationships, and validate the model
- Know how to develop alternative design choices for a given test and compare the design alternatives using a myriad of metrics for well-designed experiments

DOE 3: Experimental Design and Analysis – Response Surfaces

Target audience: DOE practitioners, operations analysts, test project engineers, test engineers, scientists, and statisticians. This course also serves as the final week of the 3-week series for operations analysts and test engineers, and serves to hone the most important DOE concepts and tools.

Prerequisite: DOE 2 or instructor consent

Duration: 4 days

Description: This is the third course in a series of experimental design and analysis courses covering the essentials of a recommended strategy for test and evaluation. This course extends experimental design concepts to provide a full complement of test matrix alternatives capable of accommodating many variables over multiple testing periods (missions, days, and sessions) with a variety of objectives to include characterization, prediction and optimization. Efficient fractional factorial designs for 2-levels or more are addressed. Another primary topic is response surface methods, including designs for nonlinear systems and strategies to find optimal settings for the test variables. Multiple effectiveness measure studies are also covered. In addition, we discuss proper experimentation and analysis practices when the principle of randomized run order is not practical (split plot designs) or when the collected data is either binary or is continuous and skewed. Design expert is the primary software program used for this course, but SAS JMP will be demonstrated as well. The graduate of this 3-course sequence will be fully trained in Design Expert and capable in JMP to practice the basic concepts of real-world DOE and able to exercise the discipline independently.

Objectives: People who complete this training will:

- Comprehend the use of DOE across military test projects by studying over a dozen example cases in detail
- Know the details behind the methods for 2^k and fractional 2^{k-p} designs by review and in-depth study
- Use Design Expert or SAS JMP to design, examine, and analyze factorials and fractional factorials
- Know the design and analysis techniques for fitting nonlinear input/ output relationships – 2nd order models
- Understand the methods for optimization of second order systems or experiments involving multiple responses
- Know the split plot design and analysis approach, which is necessary when complete randomization is not practical
- Understand the benefits of optimal designs for mixed level fractions, constrained input spaces, high-order models, special case augmentation constrained input spaces, and high-order models

DOE 4: Experimental Design and Analysis – Advanced Topics

Target audience:	Energized practitioners with reasonable experience who successfully completed the three-week DOE series
Prerequisite:	DOE 3 or instructor consent
Duration:	4 days
Description:	This one-week course covers methods seasoned DOE practitioners require to handle testing aberrations. The content is geared towards equipping you with the tools for attacking the more challenging problems, where either the variable composition or underlying response surface is complex, or violations of our standard assumptions and principles occur. The intent is to dig deeper into the characteristics and qualities of the experimental designs and explore alternatives while utilizing computer generated algorithms to assist in building or augmenting designs for specific purposes. The second emphasis area is analysis: to discover alternative methods of empirical model building and performance prediction, especially when the data is messy. The final objective of this course is to provide a testing strategy when one or more factors are hard-to-change. The format of the course will blend lecture, case studies, and extensive use of analytical software. Both Design expert and JMP are used in this course. We will delve into topics selected from the following list, depending on student needs: • Empirical Data Modeling, Observational Studies • Optimal Designs • Space-filling Designs, Factor Covering Arrays • Robust Parameter Design • Multiple Responses • Random Effects, Mixed Models and Variance Components • Sequential Design & Augmentation/Validation/Prediction • Split Plot Design and Analysis • Second-order Designs/Modeling • Nested Factors and Analysis of Covariates (ANCOVA) • Binary, Discrete and Non-normal Response Modeling

Split-Plot Design and Analysis

Target audience:	DOE practitioners, operations analysts, test project engineers, test engineers, scientists, and statisticians. This course also serves to hone some of the most important DOE concepts and tools when at least one of the factors is hard to change.
Prerequisite:	Some familiarity with how designed experiments or tests are usually conducted and how statistical analyses are performed
Duration:	1 day
Description:	Have you ever built what you considered to be the ideal designed experiment, then passed it along to be run and learn later that your recommended run order was ignored? Or perhaps you were part of a test execution team and learned too late that one or more of your experimental factors are difficult or time-consuming to change. We all recognize that the best possible guard against lurking background noise is complete randomization, but often we find that a randomized run order is extremely impractical or even infeasible. Split-plot design and analysis methods have been around for over 80 years, but only in the last several years have the methods fully matured and been made available in commercial software. This class will introduce you to the world of practical split-plot design and analysis methods. We'll provide you the skills to effectively build designs appropriate to your specific needs and demonstrate proper analysis techniques using general linear models, available in the statistical software. Topics include split-plots for 2-level and mixed-level factor sets, for first and second order models, as well as split-split-plot designs. You are encouraged to bring laptops and follow along. Demonstrations, case studies and in-class exercises will be emphasized using JMP (free download at jmp.com) and Design Expert (free at statease.com) statistical software packages
Objectives:	People who complete this training will: • Appreciate the benefits of applying the fundamental principle of complete randomization in executing a designed experiment • Understand times or situations when complete randomization is not practical or even feasible • Know the differences between a completely randomized design and a split-plot design • Understand the reasons for proper structuring of a split-plot design • Appreciate split-plot design aspects to focus on and emphasize when planning and assessing the design • Know the appropriate statistical model form for properly analyzing a split-plot design • Understand the characteristic differences between first-order plus interaction model designs and designs for second-order models • Appreciate and be able to effectively build split-plot and split-split-plot designs using commercial statistical software

Statistical Power Analysis

Target audience:	DOE Practitioners, Acquisition or Test Engineers and Scientists, Program and Project Managers, Operations or Test Analysts
Prerequisite:	Some familiarity with how designed experiments or tests are usually conducted and how statistical analyses are performed
Duration:	4 - 8 hours
Description:	Statistical power calculations for designed experiments are essential to right-sizing tests during planning. Under-sized tests will fail to uncover true contributors affecting system effectiveness and suitability, while over-sized tests are wasteful. Although the concepts of statistical power are reasonably well understood, the mechanics of computations are not necessarily well publicized. The statistical software packages are not necessarily consistent in requesting user information, nor are they clear or consistent in the assumptions made for the necessary power information not requested. Because many test planning projects tend to key on pass/fail responses, we must recognize too that the software packages don't account for this type of response, so the user must take additional steps to rightly estimate power for binary responses. Most likely the least understood concept and the one software companies fail to agree upon is the method for sizing effects for categorical factors with more than two levels. These effects are critical ingredients to the power equation. So the purpose of this session is to review basic statistical power concepts as they relate to the design of experiments, discuss the differences between and the proper steps for continuous response variable power versus binary response power, describe the power formulation intricacies for designs involving multi-level categorical factors, and finally to compare software platform interfaces and power computation differences. The intent is to make you aware of the differences in power estimates across software packages, but even more importantly to equip you to confidently and successfully estimate power for your testing.
Objectives:	The student participating in this course will:

- Know the general definition and important concepts of statistical power
- Understand the ingredients to a successful power calculation
- Be able to calculate power for a simple design using a calculator or Excel
- Know the essentials for power calculations for 2-level designs
- Understand the increased complexity associated with power calculations for categorical factors with more than 2 levels
- Build designs and compute power for mixed-level full factorial and fractional factorial designs
- Be able to compute power for a design requiring statistical modeling of a binary response
- Appreciate the differences in power computations for split-plot designs and designs for binary responses and data to be analyzed using a generalized linear models

Probability and Statistics for Reliability and Reliability Growth

Target audience:	Reliability engineering practitioners, RAM engineers, project managers, statisticians, test engineers, suitability engineers
Prerequisite:	Familiarity of reliability issues and challenges, or an understanding of the need to apply probability and statistical methods to reliability problems
Duration:	4 days
Description:	Recent working groups and task forces have recognized the US governments' under-performance in reliability methods and goals and have implemented policies to significantly improve sustainment. This course covers the concepts and methods to improve a reliability program across the acquisition life cycle. The focus is on both the proactive approach of designing reliability into the system up-front (Design for Reliability) and monitoring reliability improvements through an aggressive Reliability Growth program. Attention is placed on measuring current reliability and applying probability and statistics for reliability in planning reliability tests and demonstration tests. Reliability Growth principles are also emphasized by suggesting the use of tools available to the practitioner to plan, assess, track, and project reliability. This hands-on course will use Excel and SAS JMP statistical software to reinforce analytical methods presented with demonstrations and exercises. Students will be able to construct the Reliability Growth curves now required in Test and Evaluation Master Plans for major acquisition systems.
Objectives:	The student participating in this course will:

- Know the relevance of reliability, its definition and reliability-related statistical methods
- Understand the impact of recent policy and initiatives for reliability and reliability growth
- Know reliability program requirements
- Know how to develop reliability predictions
- Know how to plan reliability tests
- Know how to determine sample size
- Understand Design for Reliability (DfR) with Fault Tree Analysis and Failure Modes Effects and Criticality Analysis
- Understand and apply Accelerated Life Test concepts
- Know censoring methods and parametric distribution modeling (Weibull, Lognormal, etc.)
- Understand the foundations of Reliability Growth and management's critical role
- Understand Reliability Growth Planning, Tracking, and Projection methods
- Understand repairable systems, software reliability and the impact of reliability on costs
- Understand how reliability best practices could apply to current Air Force programs

Contact:

Jim Simpson, PhD
Principal Consultant
JK Analytics, LLC
jim@jkanalytics.com
850-797-7005

Dr. Simpson has blended practical application and industrial statistics leadership with professional and academic experience focused on researching new methods, teaching excellence and the development and delivery of statistics courseware for graduate and professional education. He is a retired Air Force officer who then served as Chief Operations Analyst for the Air Force's largest test wing. He has served as full-time faculty at the Air Force Academy and Florida State University, and is now an Adjunct Professor at the Air Force Institute of Technology (AFIT) and the University of Florida. He has co-authored over 50 peer-reviewed journal articles, 4 book chapters, conducted $1.3M in research, graduated as major advisor 8 PhD / 11 MS students, and received the Florida State University Teaching Award and FSU Engineering College Research Award. He served as Editor of *Quality Engineering* journal, and as Chair, American Society for Quality Publications Management Board. He was the lead developer and instructor of 15 design of experiments statistics, reliability and test science professional short courses and has personally taught over 250 separate offerings. His courses have been formally adopted by the Air Force at AFIT as well as Department of Defense-wide courses required by the Defense Acquisition University. He is a Fellow of the American Society for Quality.