Common Test Designs

Design Type	**Description and Applicability for Operational Testing**
Full Factorial (2-level)	A design with two or more factors, each with two levels, where all possible factor combinations are tested at least once. Typically used in when the total number of factors and factor combinations is not too large (e.g., 3-5 factors). A full factorial design allows for the estimation of all main effects and interaction terms in the model. Full factorial designs tend to provide too much information (over powered) for large numbers of factors.
Fractional Factorial Design	A fractional factorial design consists of a strategically selected subset of runs from a full factorial design Useful when: Large number of factors and it is uneconomical to test every possible factor combination In screening experiments to identify the primary factors Typically, fractional factorial designs that allow for two-way interactions are adequate to characterize system performance Leverages sparsity of effects: most systems are dominated by some of the main effects and low order interactions
Full Factorial Design with center points	Center points add the ability to check for curvature across continuous factors Provide small increases to statistical power
Full Factorial (2-level) replicated	Replication can be used to increase statistical power and provide estimates of variation within a condition Often not possible in cost constrained operational tests In a constrained resource environment it is better to cover more of the operational space than to replicate (i.e., do not eliminate a factor for the sake of replication) A common middle ground is to only replicate a subset of the design (e.g., a center point)
General Factorial	Similar to a two-level factorial design a general factorial design has two or more factors, each with two or more levels, where all possible factor combinations are tested at least once. Only possible when the number of factors is not too large (e.g., 3-5 factors). Allows for the estimation of all main effects and interaction terms in the model. Less powerful as you add more levels to each factor For continuous factors, two-levels provides the highest power

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Response Surface Designs	Response Surface Methodology is a collection of experimental designs Originally invented by the chemical industry to conduct sequential experimentation for process optimization Evolved to be a broad class of designs that characterize system performance Robust test design methodology fits second order models including quadratic effects for flexible performance characterization Types of Response Surface Designs: Central Composite Design, Face Centered Cube Design, Small Central Composite Design, Box-Behnken Designs, Optimal Designs
Optimal Design	Optimize the test points for a known analysis model and sample size Optimal designs are useful: Large number of factors Highly constrained design region (disallowed combinations of factors) Large number of categorical factors The optimal design fallacy Designs that are optimal under one criteria might be far from optimal under another criteria Optimal designs are similar to factorial designs and response surface designs for similar analysis models Always build in extra points to optimal designs to allow for incorrect model assumptions and statistical power
Combinatorial Designs	Highly efficient test designs that are commonly used in testing software Do not support cause-and-effect analysis like all of the above design types, rather they cover the space very efficiently to look for problems. Root-cause analysis must be conducted if problems are found