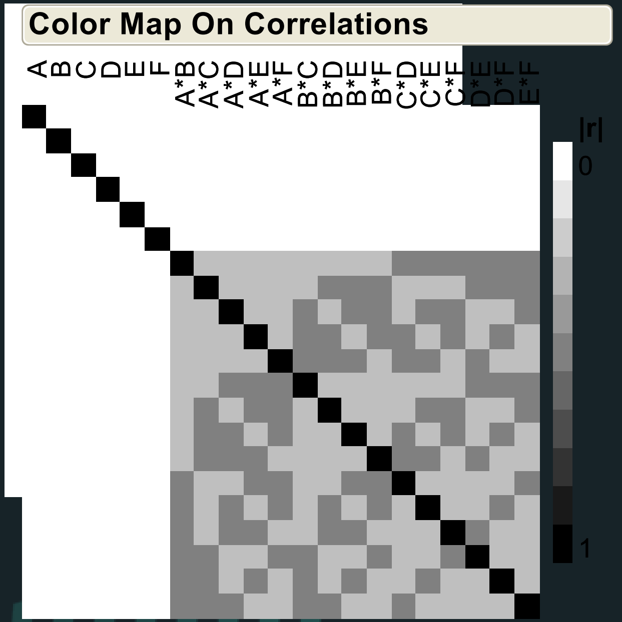
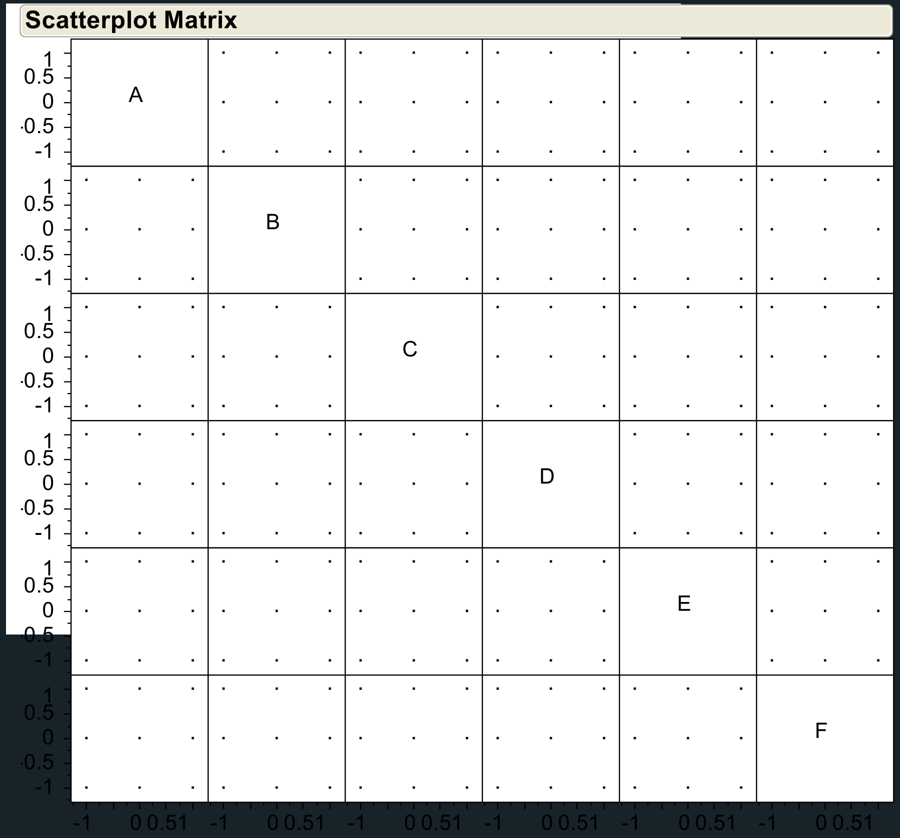
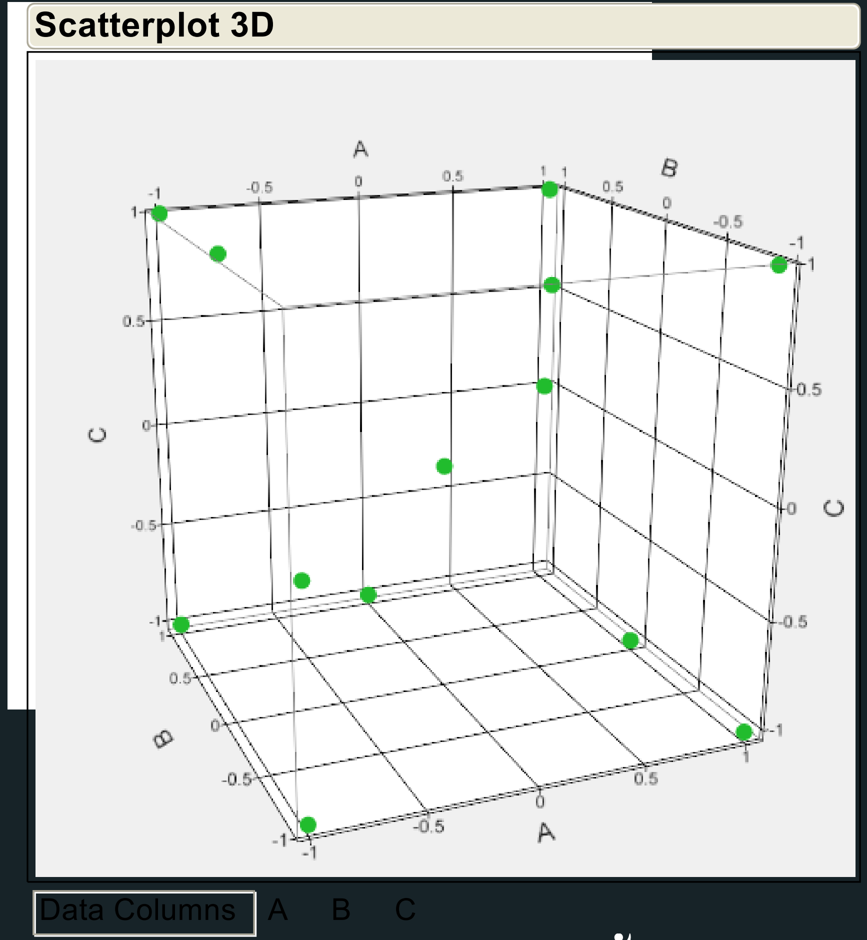
Definitive Screening Design (DSD)
Attractive alternative to
Classic 2-level screening designs

	A	B	C	D	E	F
1	0	1	-1	-1	-1	-1
2	0	-1	1	1	1	1
3	1	0	-1	1	1	-1
4	-1	0	1	-1	-1	1
5	-1	-1	0	1	-1	-1
6	1	1	0	-1	1	1
7	-1	1	1	0	1	-1
8	1	-1	-1	0	-1	1
9	1	-1	1	-1	0	-1
10	-1	1	-1	1	0	1
11	1	1	1	1	-1	0
12	-1	-1	-1	-1	1	0
13	0	0	0	0	0	0







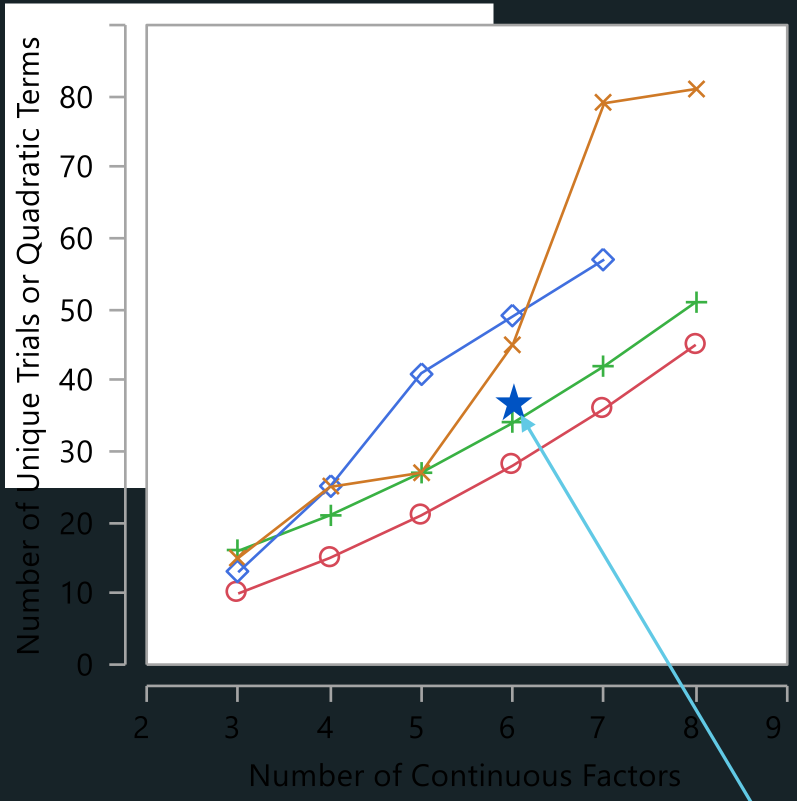
Augmentation via Custom DOE

IF MORE THAN A FEW FACTORS ARE SIGNIFICANT FOR DSD, THEN AUGMENT DESIGN TO SUPPORT 2ND ORDER MODEL

	A	B	C	D	F	G	Block	Yield @ Time t
14	0	0	0	0	0	0	1	7.49
15	1	1	-1	1	-1	1	1	0.98
16	1	1	1	-1	-1	0	1	0.86
17	-1	1	-1	-1	1	1	1	1.25
18	1	-1	1	1	-1	-1	1	1.03
19	1	1	0	-1	1	-1	1	1.07
20	0	0	0	0	0	0	1	7.33
21	1	-1	-1	0	1	-1	1	2.61
22	-1	-1	0	1	-1	1	1	11.39
23	-1	0	1	-1	1	1	1	12.96
24	1	1	-1	1	1	1	1	1.18
25	1	0	1	1	-1	1	2	•
26	1	-1	0	1	1	0	2	•
27	1	-1	-1	1	0	1	2	•
28	1	-1	0	-1	0	-1	2	•
29	1	0	-1	-1	1	0	2	•
30	1	1	0	-1	0	1	2	•
31	1	0	1	0	1	-1	2	•
32	-1	-1	0	0	1	1	2	•
33	0	0	1	1	-1	-1	2	•
34	-1	-1	1	0	0	0	2	•
35	0	1	1	0	1	0	2	•
36	0	1	-1	1	1	-1	2	•

NOTE: First 13 rows of original design are not shown.

These 12 trials added onto original 24 trials to support full quadratic model in 6 most important factors plus a block effect between original and augmented trials



36 trial I-optimal response-surface design started as 10-factor DSD and was then augmented with 12 more trials in 6 most important factors

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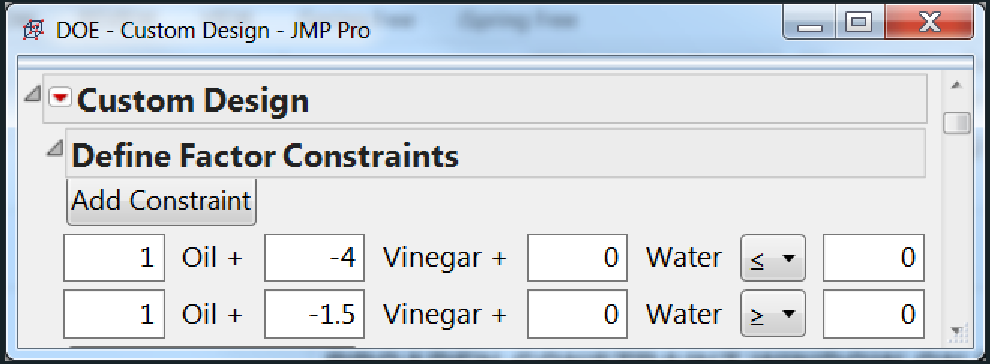
3-Component Mixture DOE with constraints

RARELY DO COMPONENTS RANGE FROM 0 TO 1,
UNLESS TAKING UP THE SLACK IN A BLEND, LIKE WATER.
VERY OFTEN ADDITIONAL CONSTRAINTS

Study mixture components in a DOE use ranges that are proportions:

O:	0.500 to 0.750	(½ to ¾)
W:	0.000 to 0.250	(0 to ¼)
V:	0.125 to 0.375	(⅛ to ⅜)

Sum of proportions ***constrained*** to equal 1.



Ratio of Oil/Vinegar Constrained

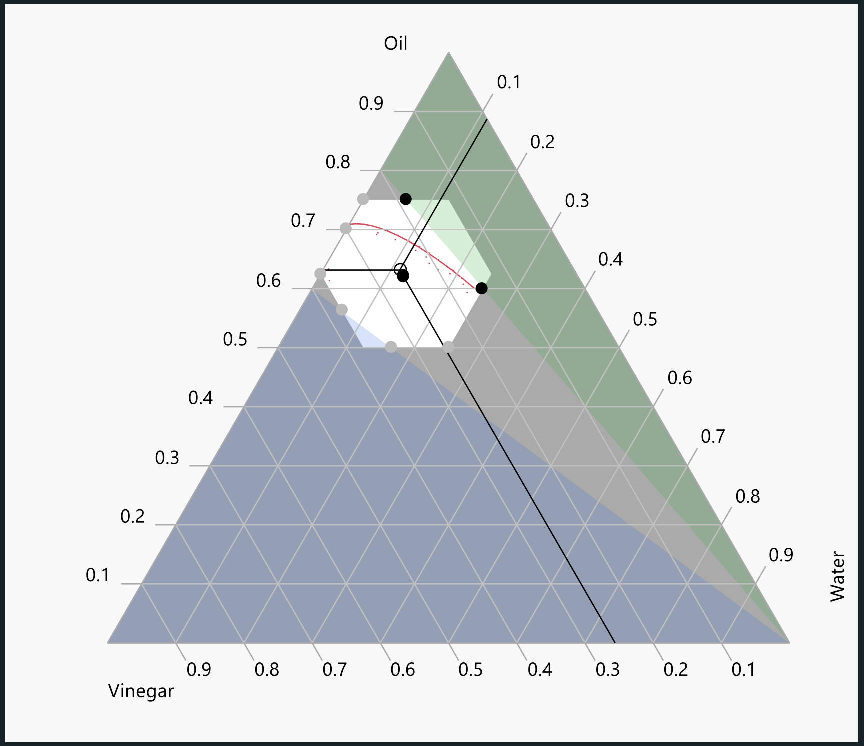
$1.5 \le O/V \le 4$

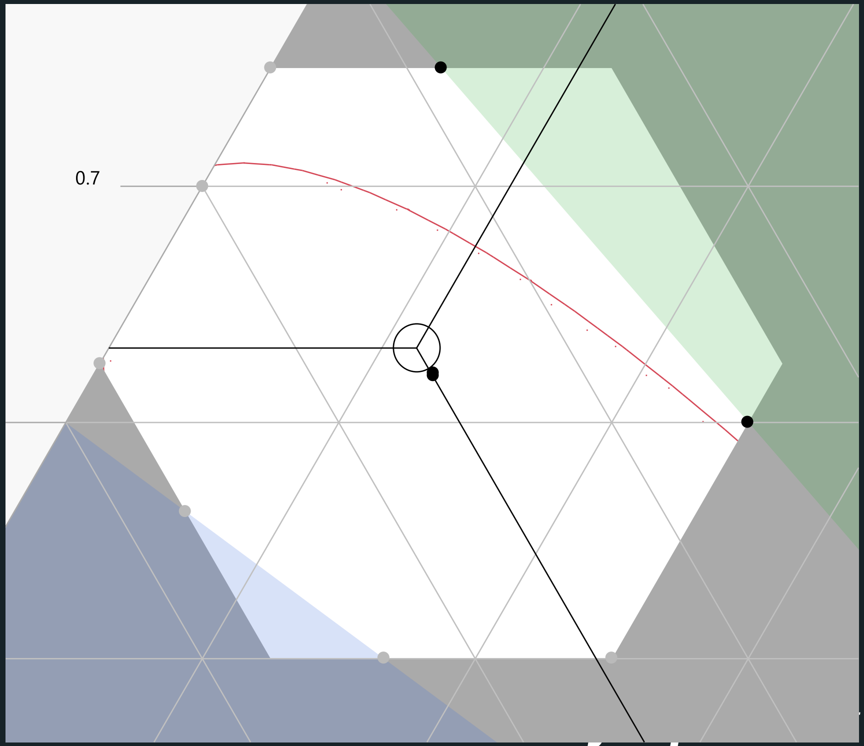
$1 = O + W + V$ so therefore…

$W = 1 - (O + V)$,

$O = 1 - (V + W)$, &

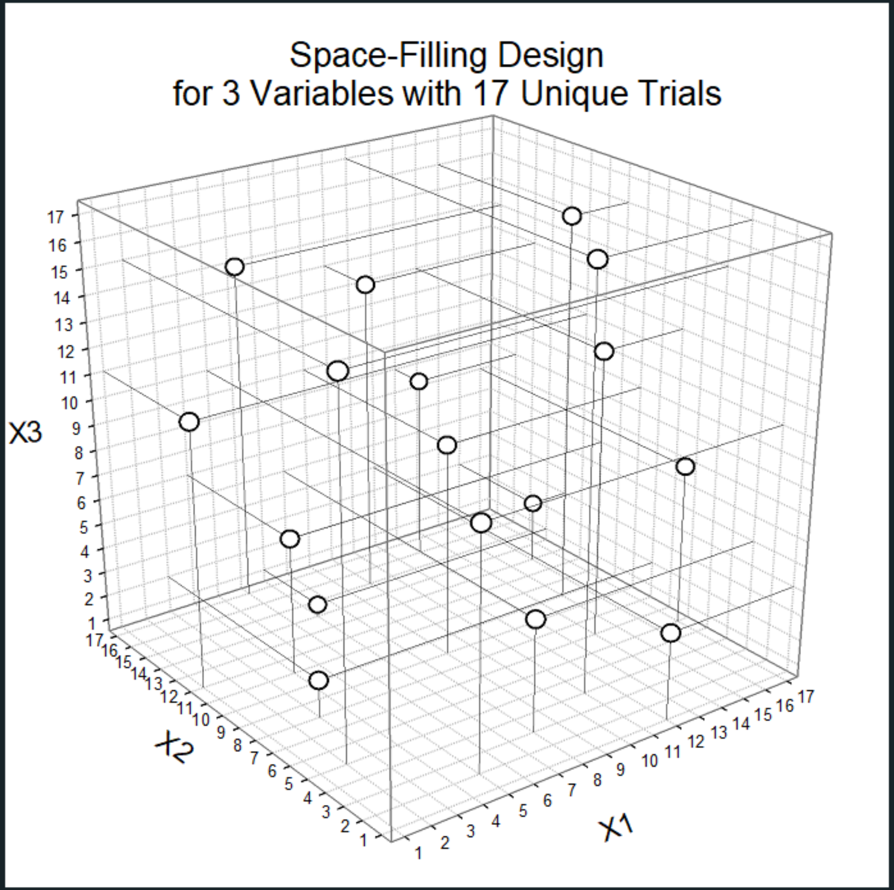
$V = 1 - (O + W)$

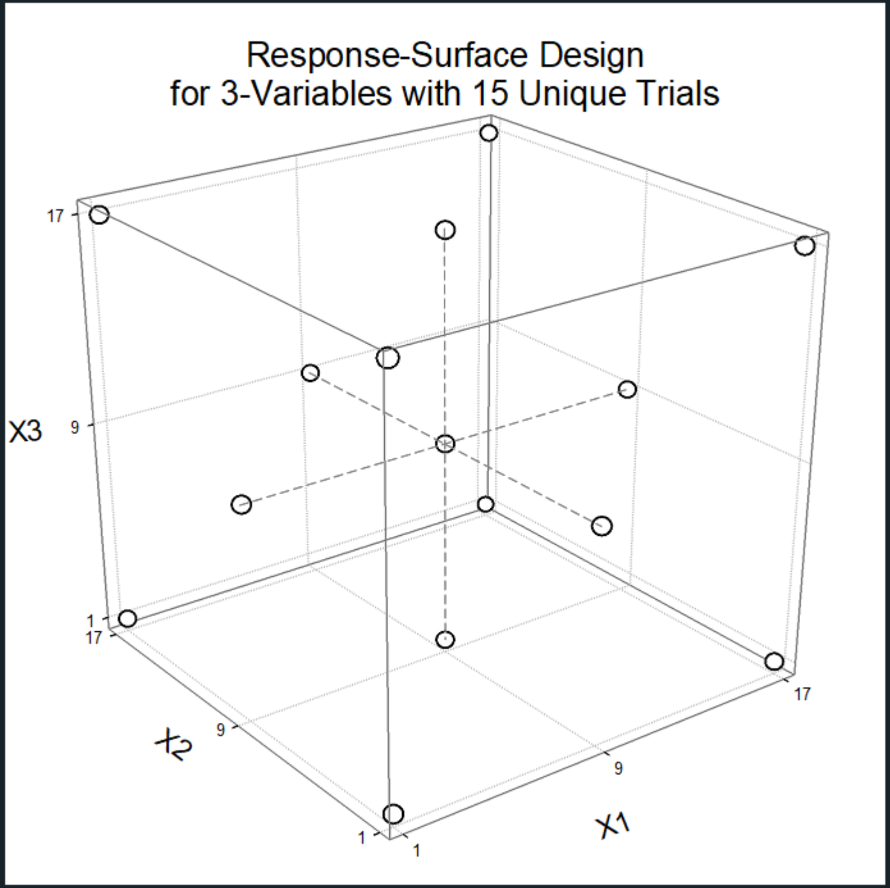




Space-filling DOE for Simulations

HOW ARE SPACE-FILLING DESIGNS DIFFERENT FROM TRADITIONAL DOE?

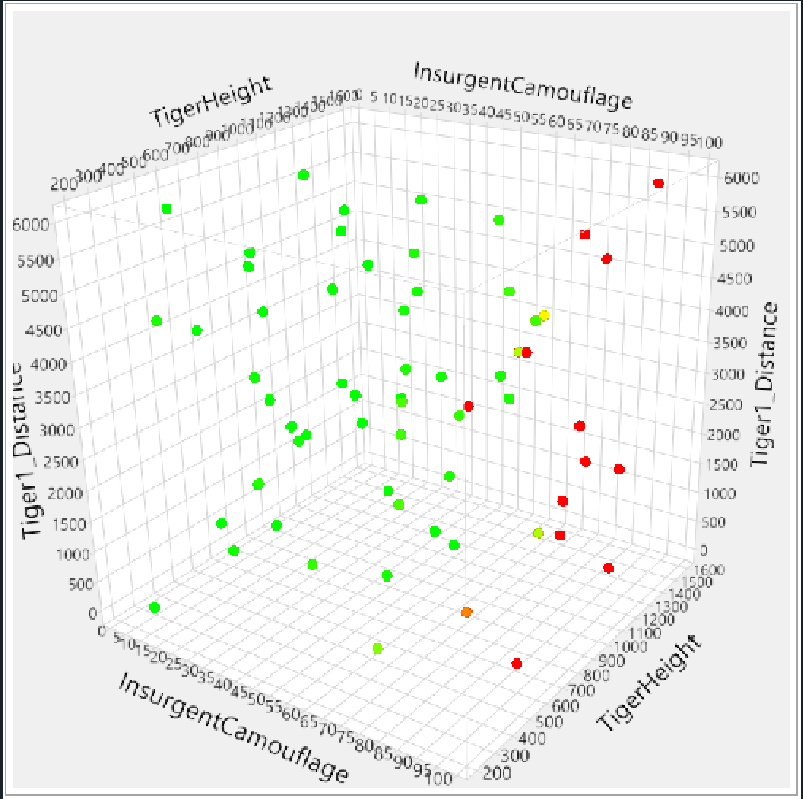


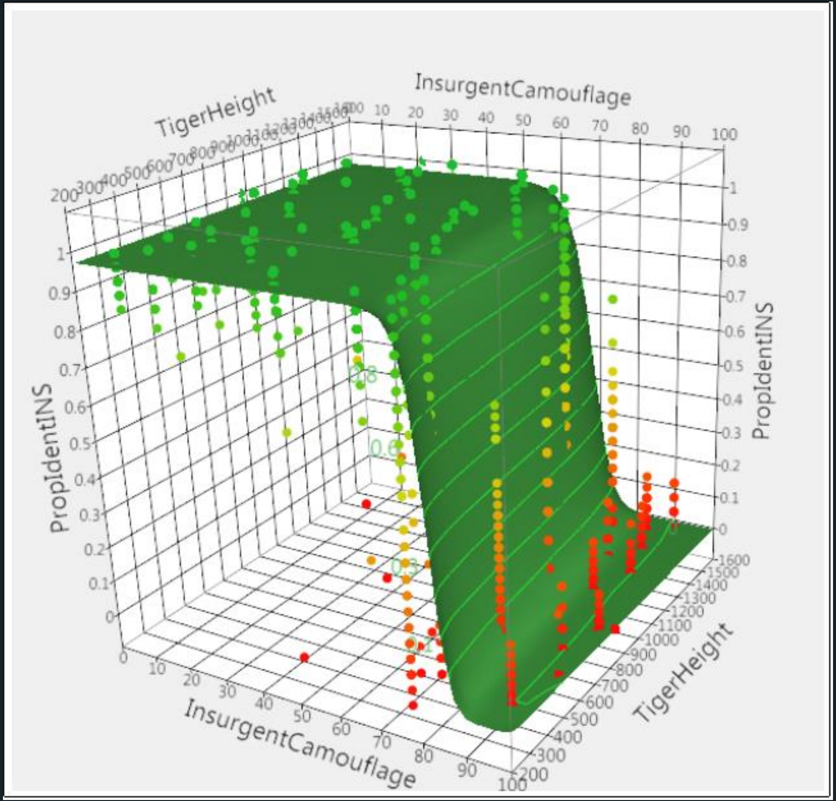


Rather than emphasizing high leverage trials ("corners") for a simple polynomial model, space-filling designs "spread" their trials more uniformly through the space to better capture the local complexities of the simulation model.

Space-filling DOE for Simulations

SPACE-FILLING DESIGNS ARE BETTER ABLE TO DETECT WHEN A PROCESS FALLS OFF A CLIFF OR HAS A SPIKE

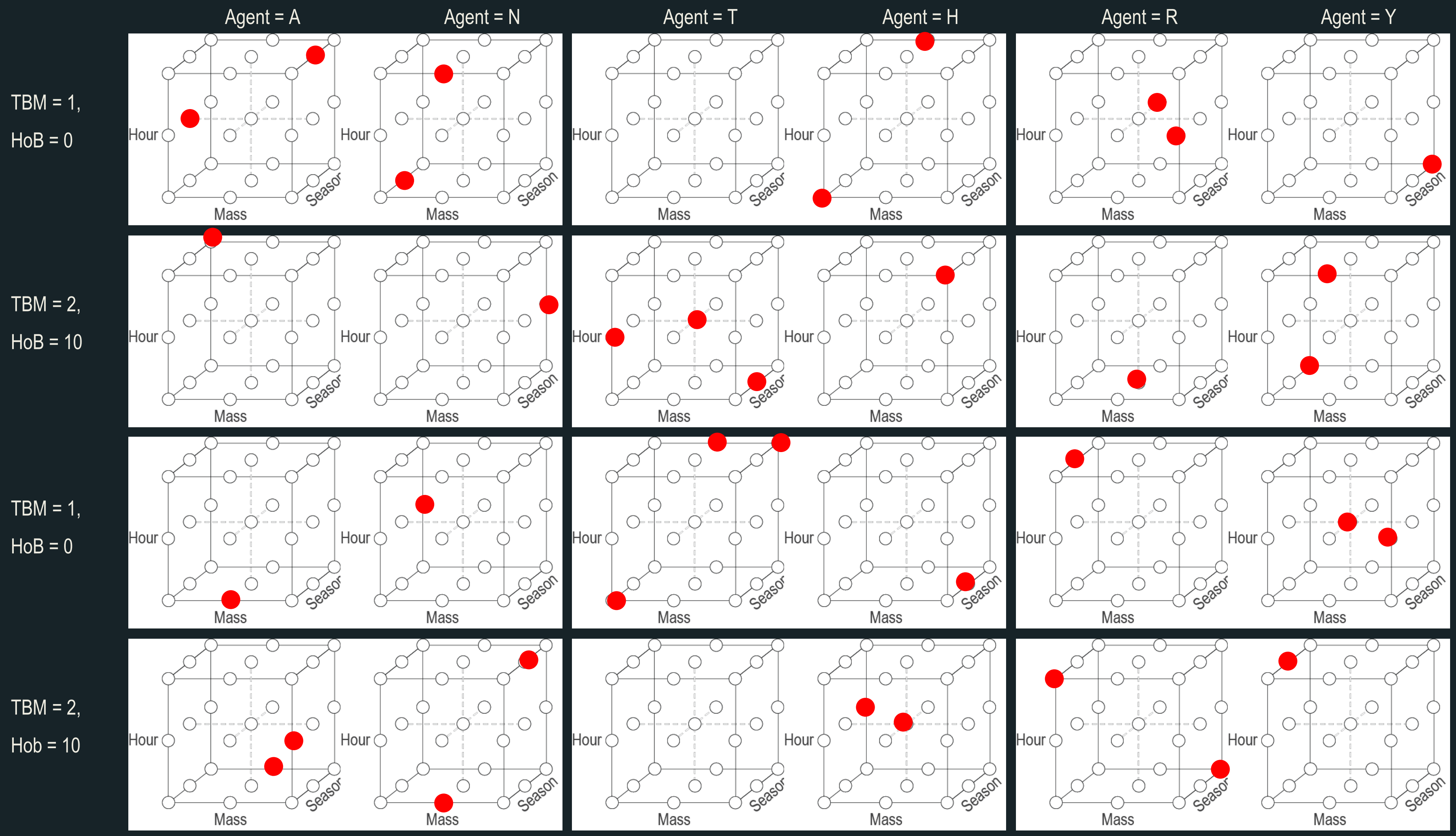




Rather than emphasizing high leverage trials (“corners”) for a simple polynomial model, space-filling designs “spread” their trials more uniformly through the space to better capture the local complexities of the simulation model.

Sequential Experimentation

36 OF ALL 648 POSSIBLE COMBINATIONS OF SETTINGS FOR 6 VARIABLES (6 X 2 X 2 X 3 X 3 X 3)



Red Dots Mark the 36 Trials (an Orthogonal Array) Analyzed for Stage 1

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Sequential Experimentation

FOUR STAGE DESIGN SUPPORTING INCREASING COMPLEXITY OF MODEL

Stage 1

36 Total Simulations

Design 1, 36 trials

Main effects only for ALL variables
+ some 2-way interactions

5.6% of 648

Stage 2

108 Total Simulations

Design 1, 36 trials

Design 2, 72 trials

Stage 1 effects plus all 2-way interactions
+ some 3-way interactions

16.7% of 648

Stage 3

324 Total Simulations

Design 1, 36 trials

Design 2, 72 trials

Design 3, 216 trials

Stage 2 effects plus all 3-way interactions

50% of 648

Stage 4

ALL **648** Simulations

Design 1, 36 trials

Design 2, 72 trials

Design 3, 216 trials

Stage 3 effects plus ALL remaining 4-way, 5-way and 6-way interactions

Design 4, 324 trials

NOTE: Length of this green box should be longer than shown

324 trials in Design 4 used as checkpoints for Designs 1, 2 & 3 →

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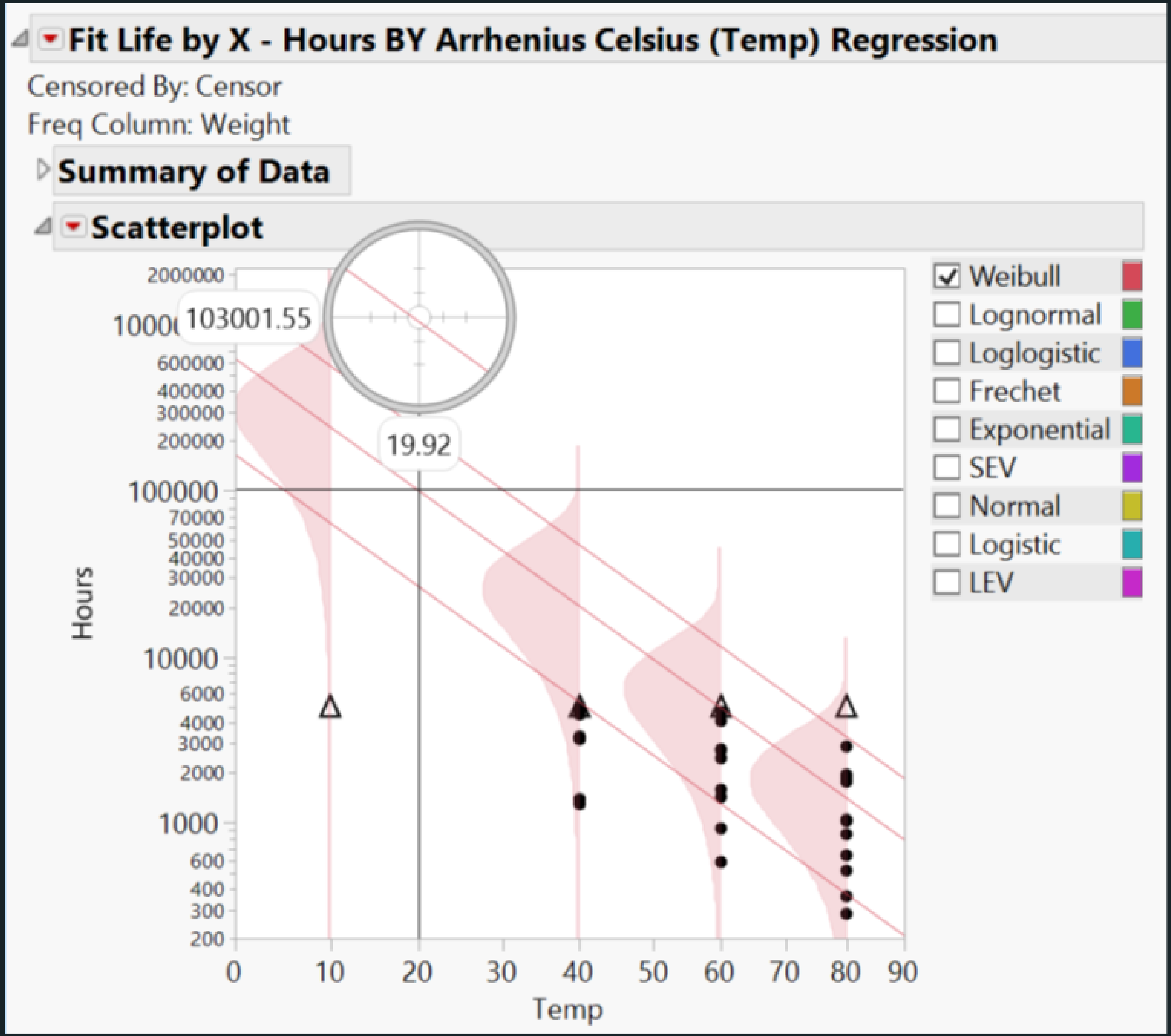
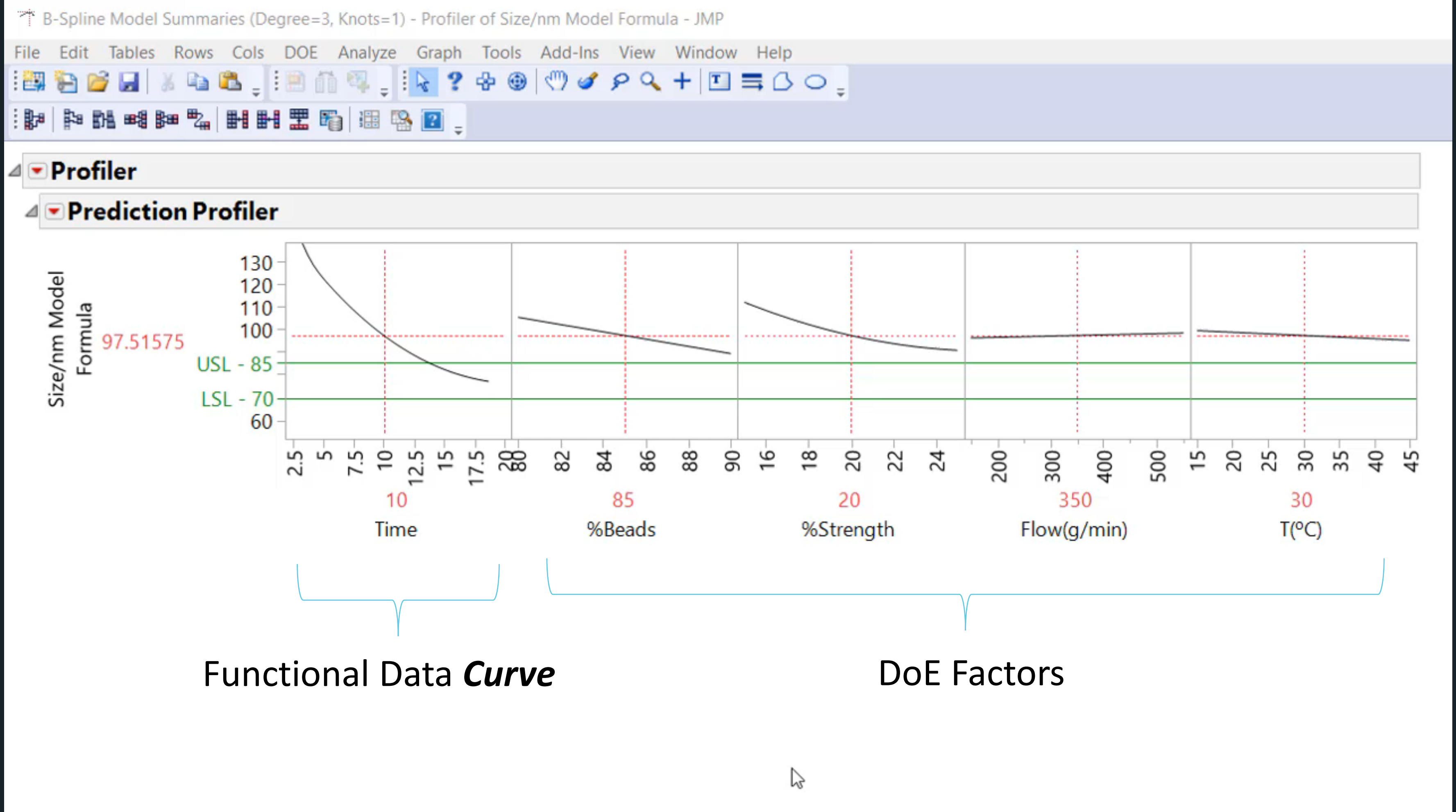
Accelerated Life Test Design

TAKE TRIALS WHERE THEY GIVE THE BEST INFORMATION

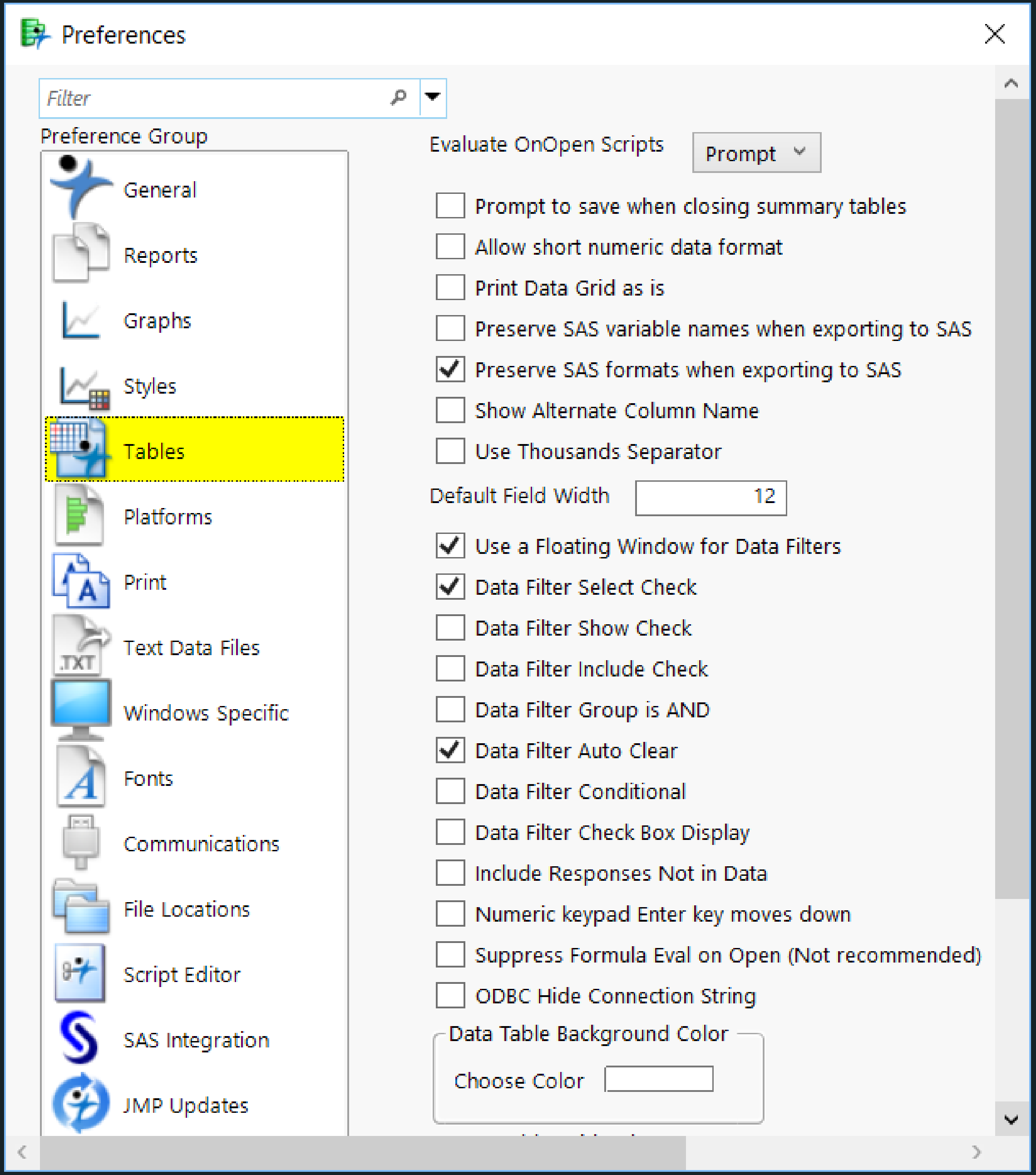


Functional Data Analysis for DOE

MODELING THE "SHAPE" OF A STREAM OF DATA – SHAPE IS THE FUNDAMENTAL UNIT OF OBSERVATION – DIMENSION REDUCTION WITH FUNCTIONAL PCA



Covering Arrays Fewest Tests for N-way Coverage



Twenty check boxes in this dialog box

2^{20} = 1,048,576 possible combinations

How many tests to check:

All pairs?

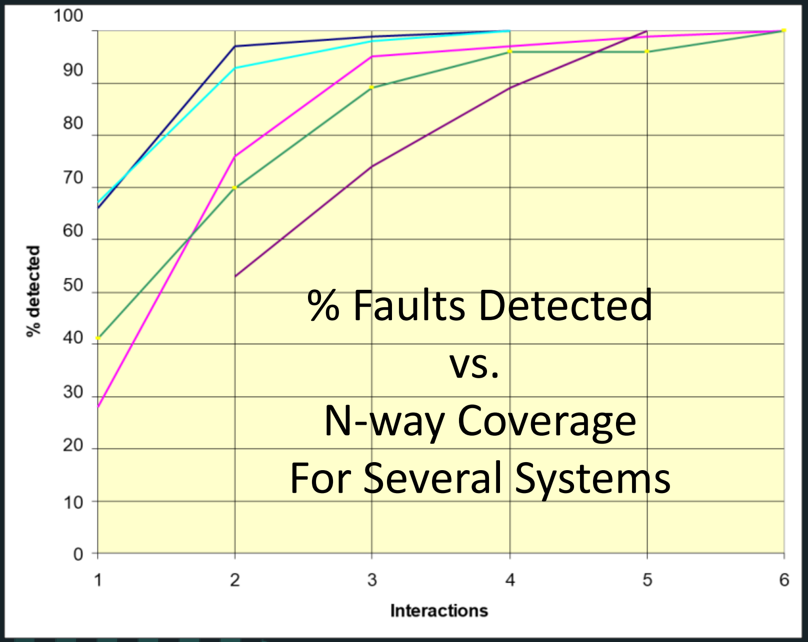
All triples?

All quadruples?

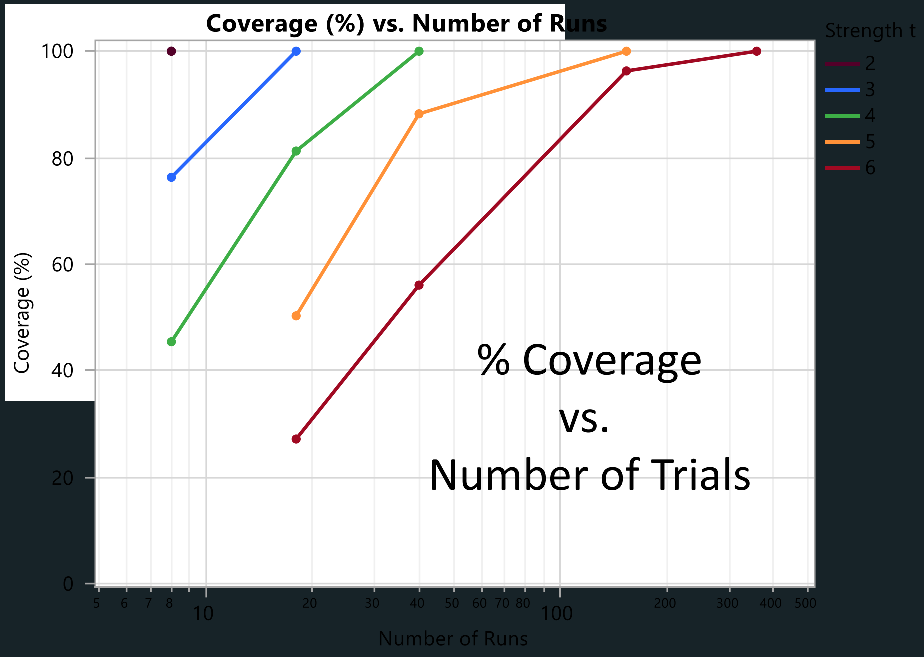
All quintuples?

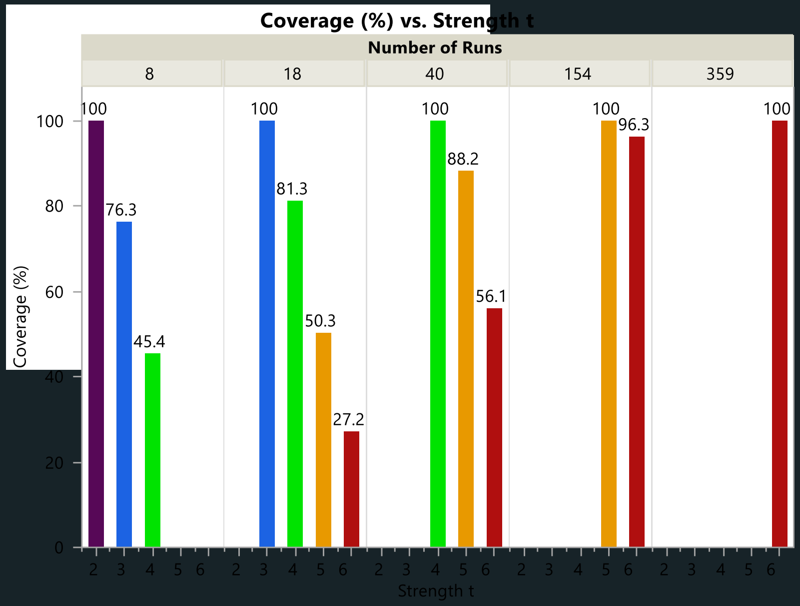
All sextuples?

Covering Arrays Fewest Tests for N-way Coverage



Graph courtesy of Rick Kuhn, NIST





Number of Runs: 8

t	Coverage	Diversity
2	100.00	50.00
3	76.32	76.32
4	45.43	90.87

Number of Runs: 18

t	Coverage	Diversity
3	100.00	44.44
4	81.25	72.22
5	50.30	89.42
6	27.16	96.57

Number of Runs: 40

t	Coverage	Diversity
4	100.00	40.00
5	88.24	70.59
6	56.07	89.71

Number of Runs: 154

t	Coverage	Diversity
5	100.00	20.78
6	96.39	40.06

Number of Runs: 359

t	Coverage	Diversity
6	100.00	17.83

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