Method for Developing an Objective Rating Scale for Probe Debris

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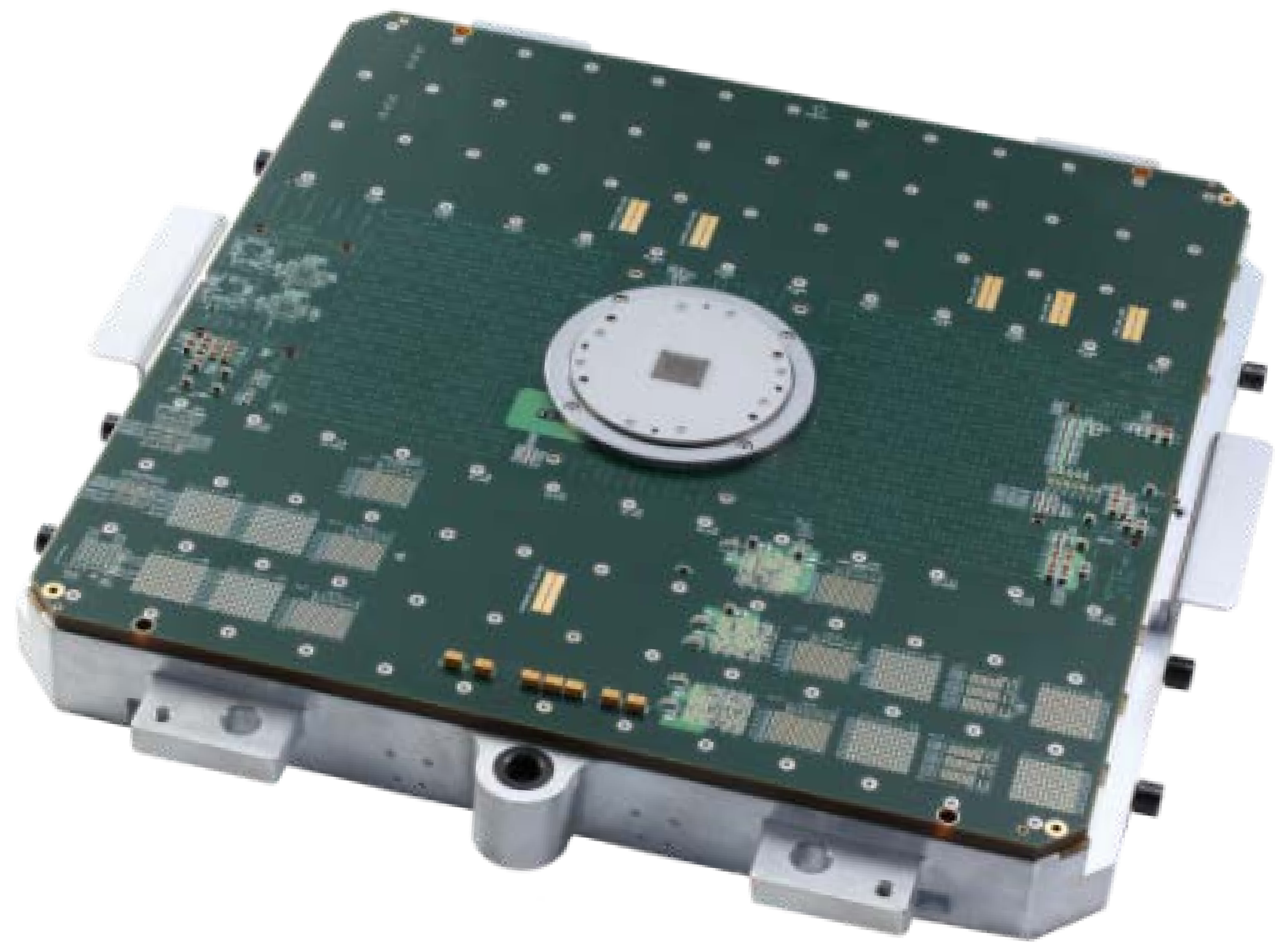
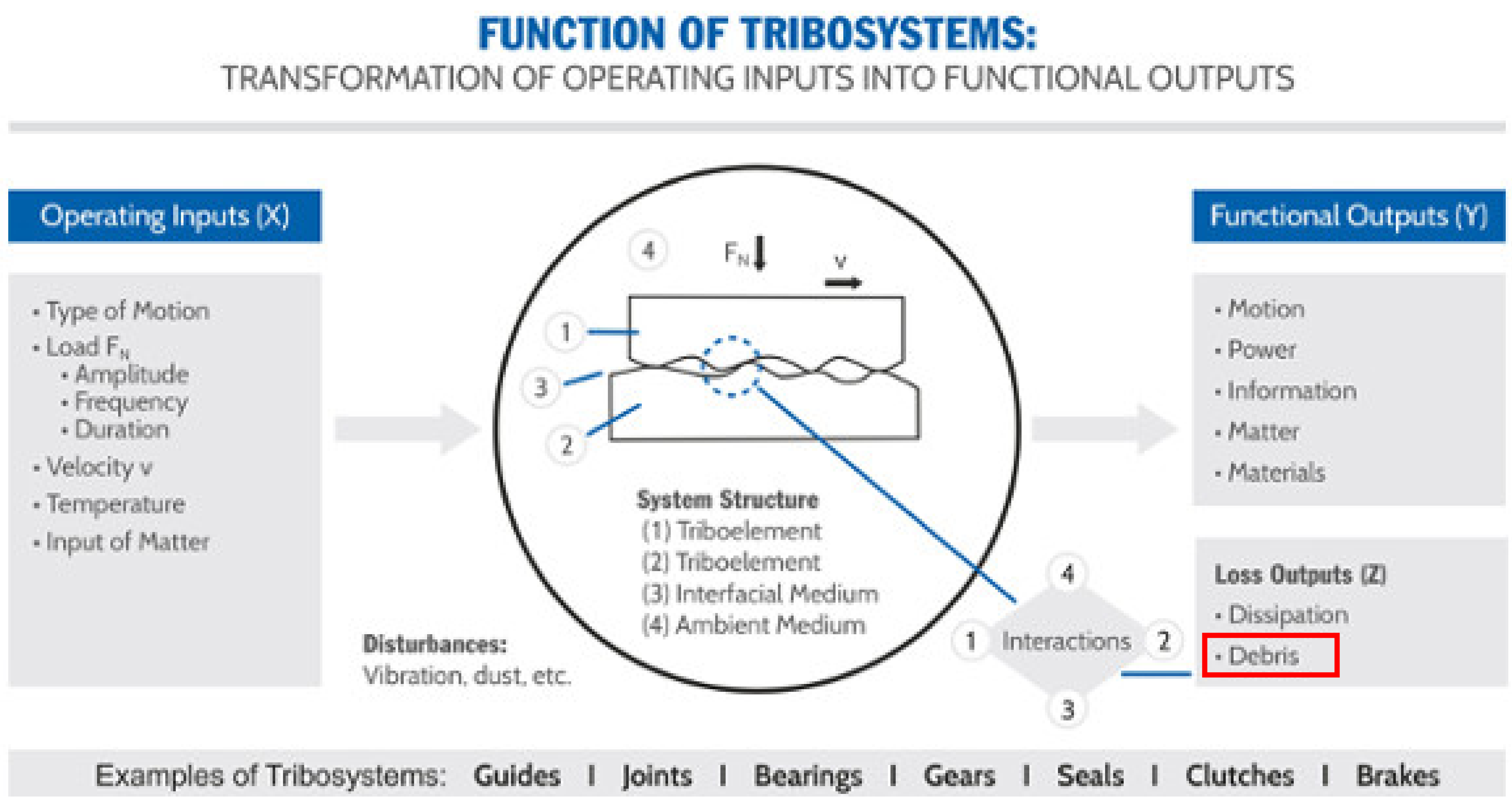
Background

Wafer fabs are among the cleanest environments on earth....



...and probe cards are part of this environment.

But, like any system of multiple surfaces in relative motion with frictional contact, vertical probe cards generate debris:

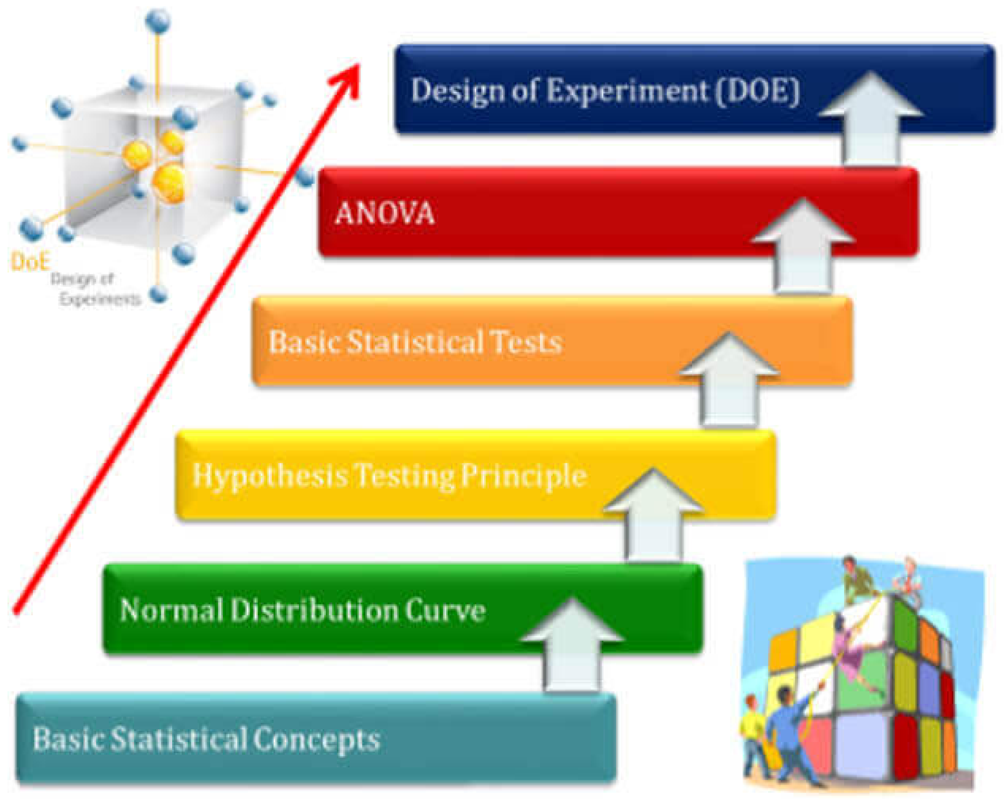


Problem Statement

Aside from being a potential source of contamination on the test floor, debris can be problematic because:

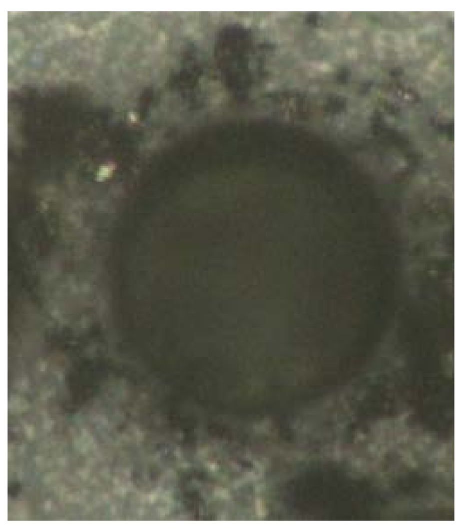
- Higher debris generation tends to indicate higher friction
  - Friction in the probe head reduces the force transmitted to the space transformer, thus impacting contact
- Excessive debris generation can lead to stuck probes

∴ <u>In general, debris should be minimized to reach optimal probe card performance</u>



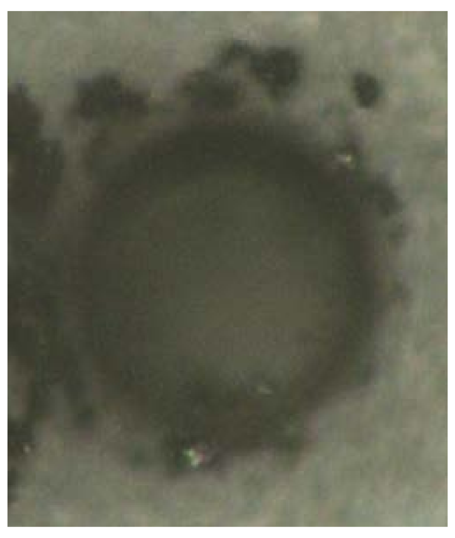
Design Of Experiments (DOE) is a powerful tool to optimize performance However, successful DOE analysis depends on objective, quantifiable results from controlled experiments

Probe card debris is subjective – since some debris is inevitable, how much is too much? Can you reliably tell which of these probes is better or worse in debris generation? And would a different observer agree with your assessment?



?

vs.



Method

1. Identify variables to study and create DOE test plan:

Design Type: 3 variables, 2 levels, 2^3 --> 8 runs, full-factorial				Responses				
Std. Order	**Variable A**	**Variable B**	**Variable C**	**Debris**	**BCF**	**Cres**	**Planarity**	**Alignment**
1	Level 1	Level 1	Level 1					
2	Level 2	Level 1	Level 1					
3	Level 1	Level 2	Level 1					
4	Level 2	Level 2	Level 1					
5	Level 1	Level 1	Level 2					
6	Level 2	Level 1	Level 2					
7	Level 1	Level 2	Level 2					
8	Level 2	Level 2	Level 2					

2. Establish standard debris photo parameters to allow for easier head-to-head comparison:

20x zoom, focused on guide plate

34 photos needed for whole array

Name photos according to following convention:

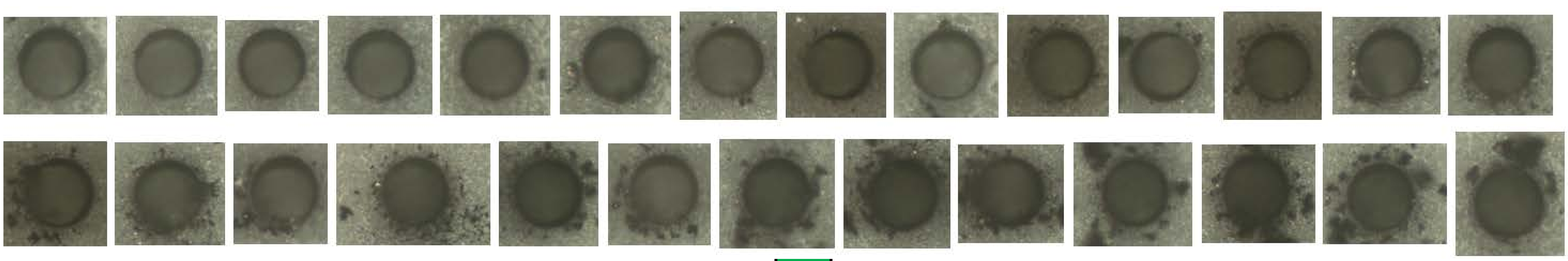
DXX_PY_ZZZZ

X = DUT # (1-8; include all DUTs shown in photo)

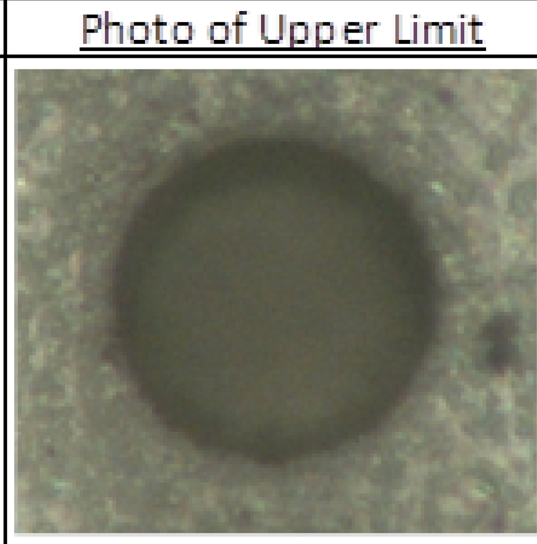
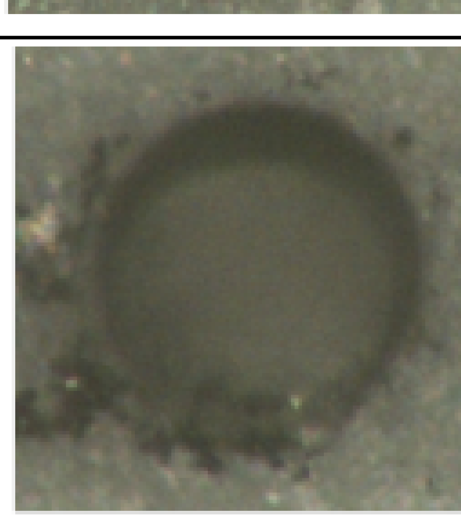
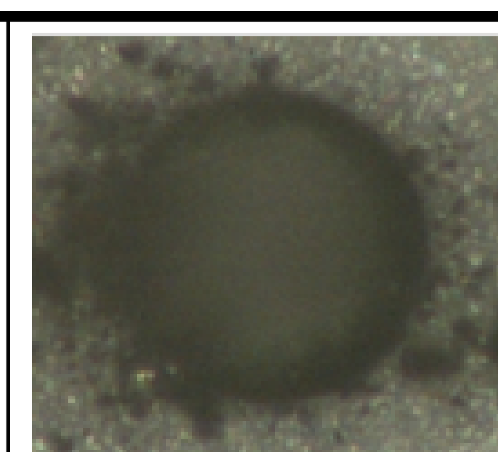
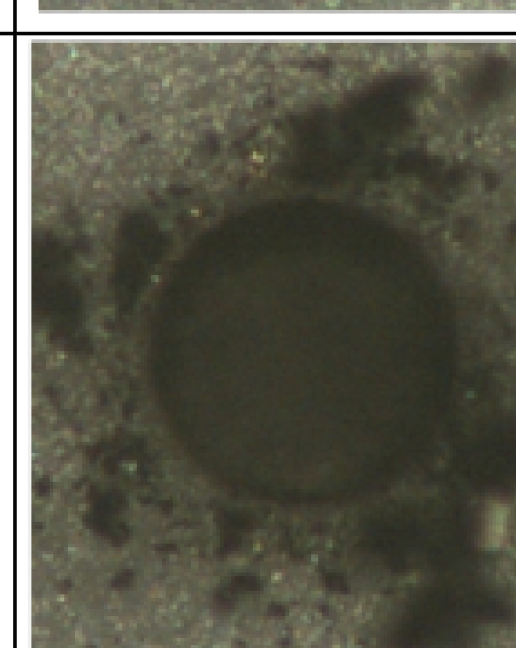
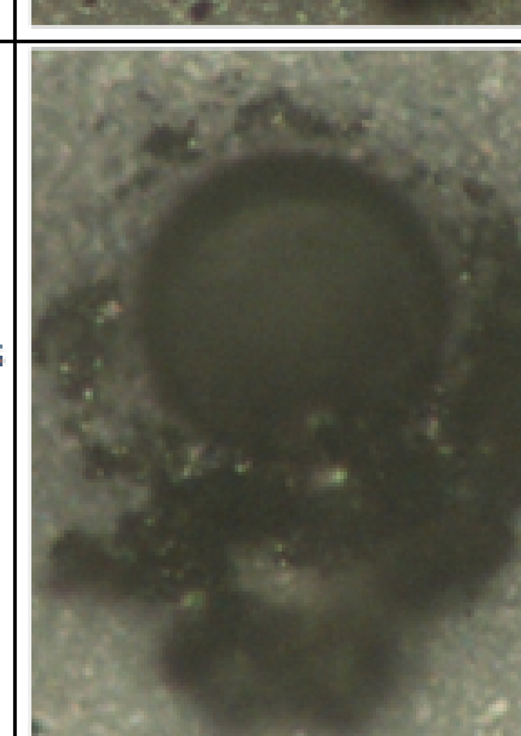
Y = position on DUT (A-D)

Z = measurement point (INIT, 100k, 200k, etc.)

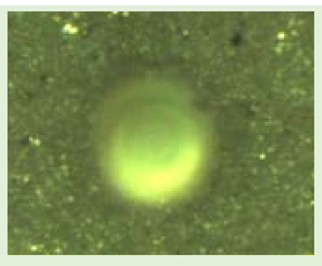
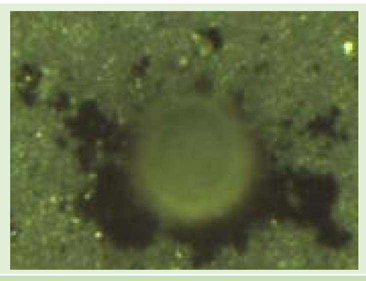
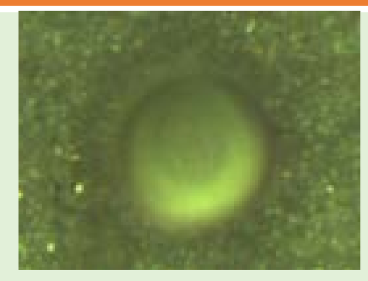
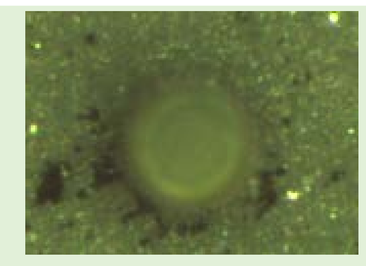
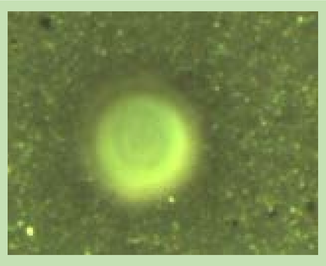
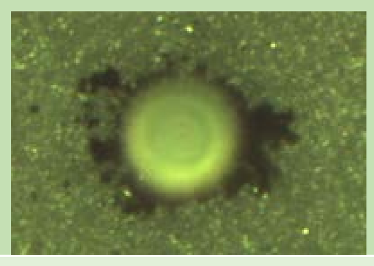
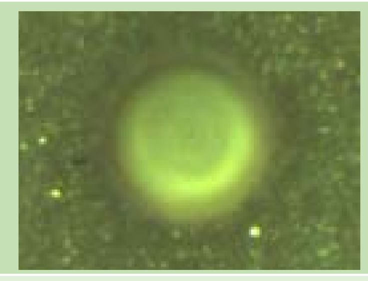
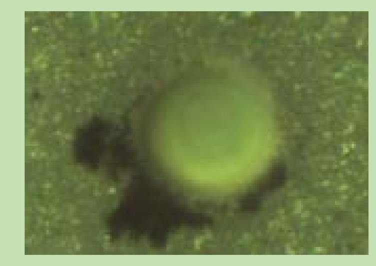
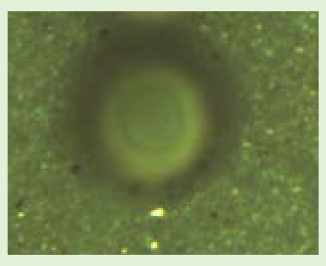
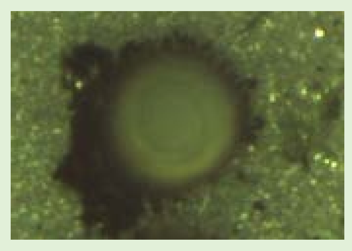
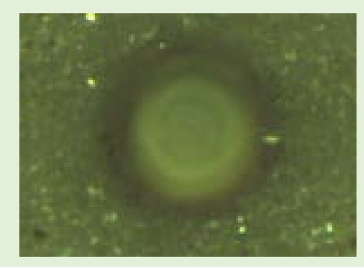
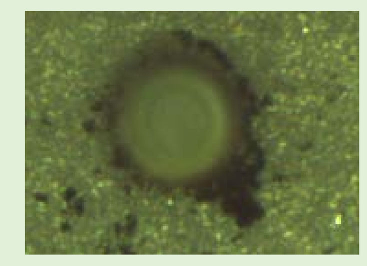
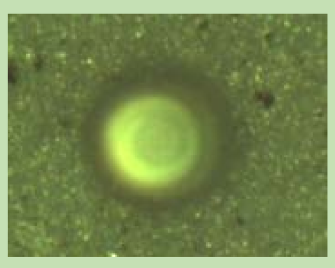
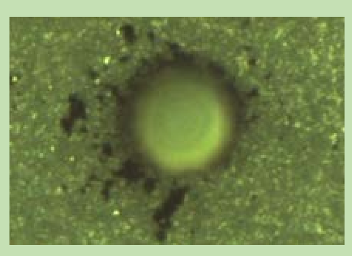
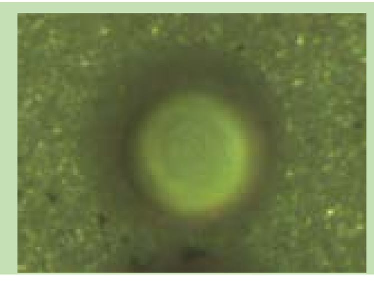
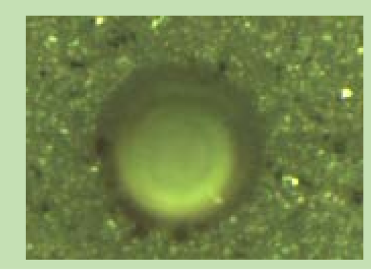
3. Collect initial debris photos, arrange in order, and grades & limits

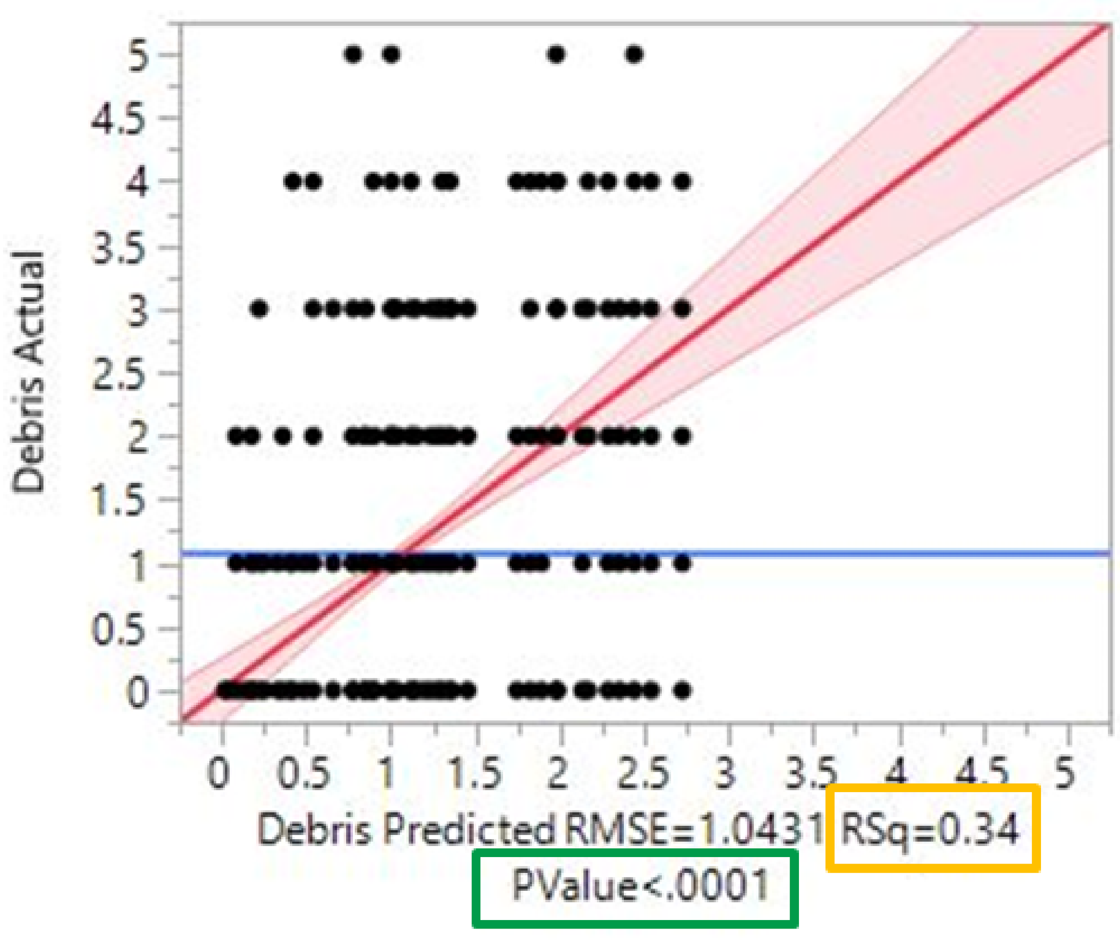


Debris Categories:

Number	Description	Photo of Upper Limit	Instructions
0	Very little or no debris; essentially debris-free		If the probe has less debris than the photo, give it a score of zero
1	Slight debris at several locations around probe, but not excessive and not forming continuous sections around the probe		If the probe has less debris than the photo but more than the photo of category zero, give it a score of one
2	Moderate debris forming one or more continuous sections, but not extending completely around the probe		If the probe has less debris than the photo but more than the photo of category one, give it a score of two
3	Moderate to severe debris extending around 1/3 or more of the probe		If the probe has less debris than the photo but more than the photo of category two, give it a score of three
4	One or more large debris piles, with debris present all the way around the probe		If the probe has less debris than the photo but more than the photo of category three, give it a score of four
5	Very large debris piles; this is the worst category for debris		If the probe has more debris than the photo of category 4, give it a score of five

Results

DOE Group	Best Case Example	Worst Case Example	DOE Group	Best Case Example	Worst Case Example
1			5		
2			6		
3			7		
4			8		



Pvalue is low (lower is better; significance threshold is <0.05 for 95% confidence): we can say with at least 95% confidence that differences between group means are significant

R-squared value is relatively low (higher is better; % of variation explained by model): model fit does not fully account for variation in data

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	10	404.1020	40.4102	37.1420
Error	709	771.3855	1.0880	**Prob > F**
C. Total	719	1175.4875		<.0001*

Analysis of Variance (ANOVA): Sum of squares of Error is higher than Model

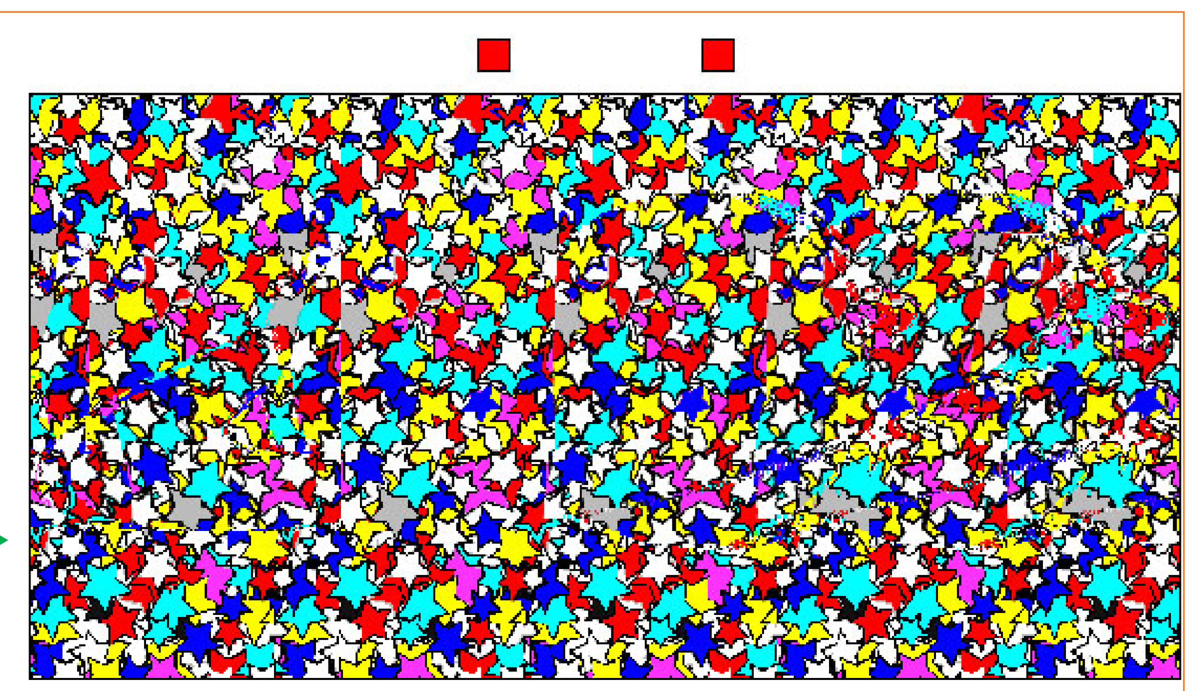
Source	LogWorth		PValue
Variable A	40.678		0.00000
Variable B	25.347		0.00000
Touchdown Count	5.543		0.00000
Variable A * Variable B Interaction	2.032		0.00929
Variable C	2.009		0.00980
Variable C * Variable B Interaction	1.232		0.05868
Variable A * Variable C Interaction	1.095		0.08043
Variable B * Touchdown Count Interaction	0.877		0.13265
Variable A * Touchdown Count Interaction	0.324		0.47406
Variable C * Touchdown Count Interaction	0.283		0.52143

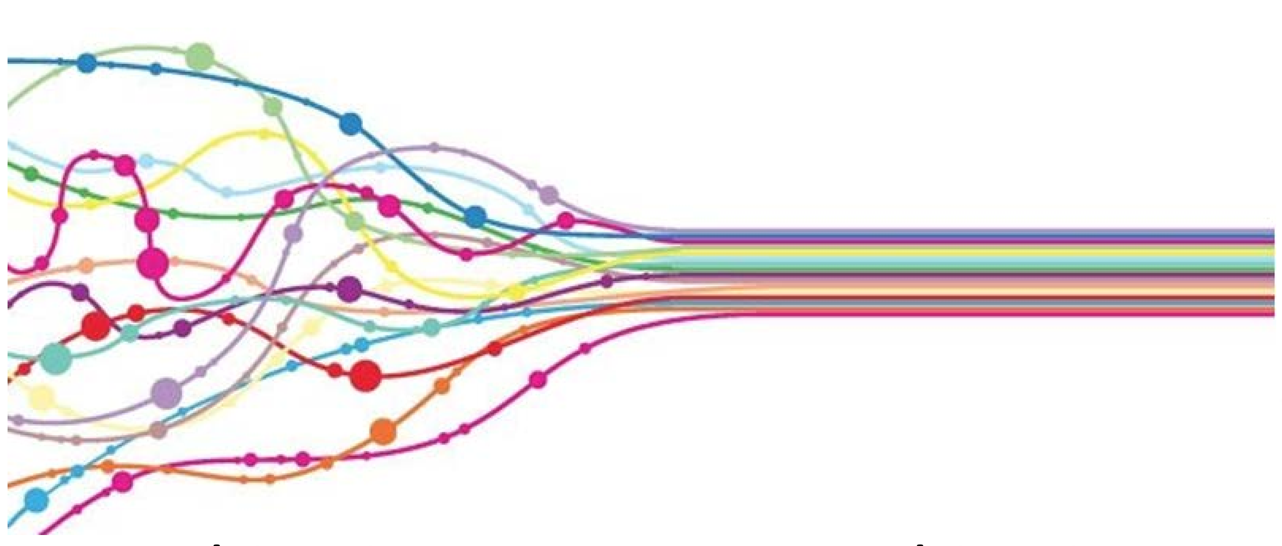
95% Significance level: Pvalue <0.05

Discussion

Despite some unexplained variation, DOE model fits the data well enough to show that Variables A and B are clearly the most significant for debris generation

→ It allows us to see the planet through the stars





Subjective Objective Optimized

More generally, this method of ranking input and establishing grades & limits can be used to quantify subjective responses for enhanced performance optimization using DOE methodology

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