Optimising 3D Printing of Drone Component: Design of Experiment(DOE)

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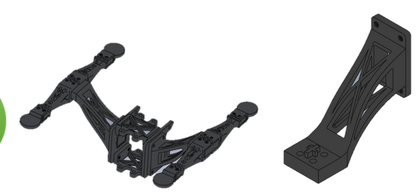
The increasing use of drones in various industries has heightened the demand for lightweight, structurally sound components, such as the main arm. 3D printing offers flexibility in manufacturing these parts, but achieving precision in dimensions like length, height, and hole positioning remains a challenge due to the influence of various factors.

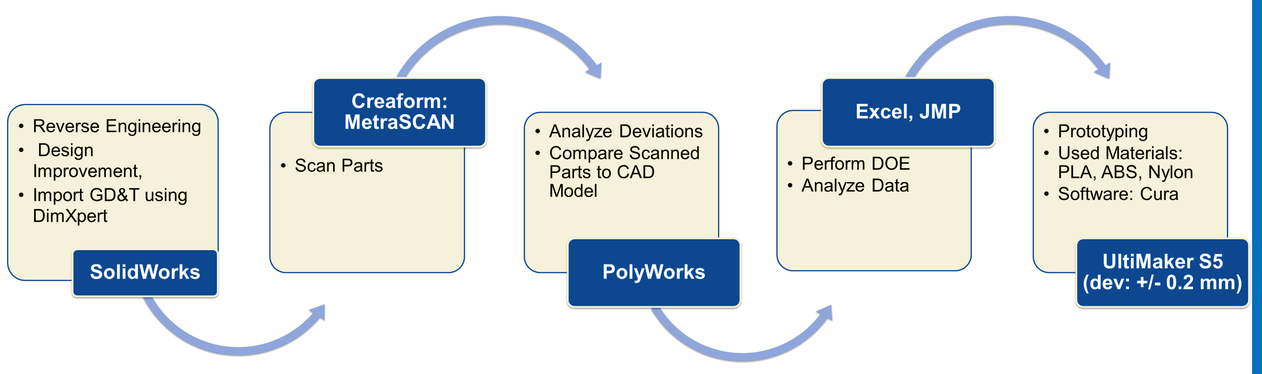
Introduction

This project focuses on optimizing the 3D printing process for a drone's main arm by investigating how factors such as printing materials, printer resolution, and part orientation influence key design parameters, including the arm's length, height, and hole positions. A full factorial Design of Experiments (DOE) was conducted to analyse these three factors, each at three levels. Advanced tools like PolyWorks and JMP were used to evaluate precise measurement data. The insights gained aim to enhance the accuracy of 3D printing for complex drone components.

Planning → Screening → Modelling → Analyzing and Optimizing → Verifying → Repeat



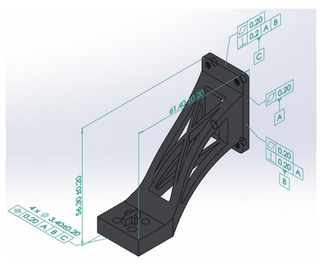
Materials



Methodology

Planning

- Choose a specific part, Import GD&T
- Identify all the potential factors



Part's orientations | Materials | Printer's settings | Strength | Support

Printer's settings: Profile, Resolutions

Strength: Infill density, Pattern, Shell thickness

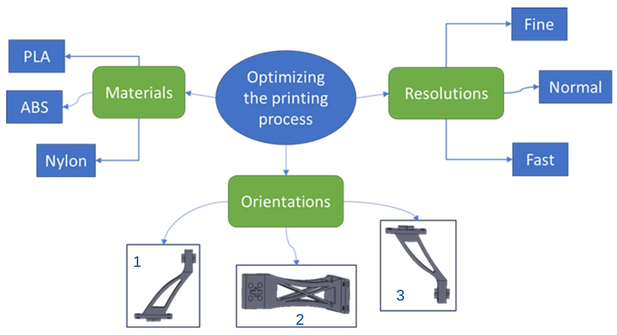
Screening

- Select the design factors and held-constant factors
- Full Factorial Design>> 3 factors at 3 levels each >> 3 ^ 3 = 27 runs
  (* Nylon cannot be printed with "fast "option.)

3x3x3 Factorial — Design: 3x3x3 Factorial; Model; Evaluate Design; DOE Dialog

Columns (7/0): Pattern, Materials, Resolutions, Orientations, Length, Height, Hole Positions

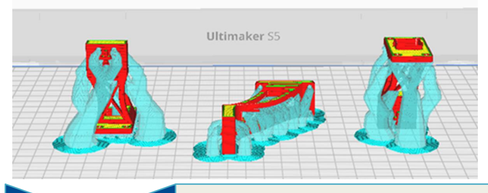
	Pattern	Materials	Resolutions	Orientations	Length	Height	Hole Positions
1	221	ABS	Normal	1	61.707	55.992	0.508
2	212	ABS	Fine	2	61.367	56.326	0.706
3	112	PLA	Fine	2	61.547	56.336	1.255
4	223	ABS	Normal	3	61.282	55.928	0.542
5	321	Nylon	Normal	1	62.336	56.044	1.501
6	331	Nylon	Fast	1	•	•	•
7	122	PLA	Normal	2	61.543	56.314	0.637
8	323	Nylon	Normal	3	61.65	55.14	0.594
9	133	PLA	Fast	3	61.622	56.139	0.847
10	123	PLA	Normal	3	61.503	56.221	0.382
11	222	ABS	Normal	2	61.284	56.135	1.185
12	333	Nylon	Fast	3	•	•	•
13	312	Nylon	Fine	2	61.463	56.222	1.305
14	121	PLA	Normal	1	61.733	56.341	0.601
15	231	ABS	Fast	1	61.491	55.958	0.762
16	132	PLA	Fast	2	61.66	56.337	0.525
17	232	ABS	Fast	2	61.531	56.36	1.004
18	313	Nylon	Fine	3	61.64	55.803	0.582
19	111	PLA	Fine	1	61.687	56.571	0.657
20	213	ABS	Fine	3	61.239	56.117	0.552
21	332	Nylon	Fast	2	•	•	•
22	131	PLA	Fast	1	61.604	56.412	0.331
23	322	Nylon	Normal	2	61.405	56.262	1.301
24	233	ABS	Fast	3	61.414	55.888	0.455
25	113	PLA	Fine	3	61.659	56.407	0.517
26	311	Nylon	Fine	1	61.891	56.009	0.876
27	211	ABS	Fine	1	61.468	56.32	0.38

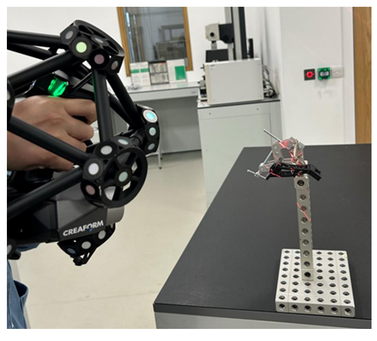


Printing and Scanning

- Scanner Resolution= 0.4 mm
- Shutter Speed= 5 ms

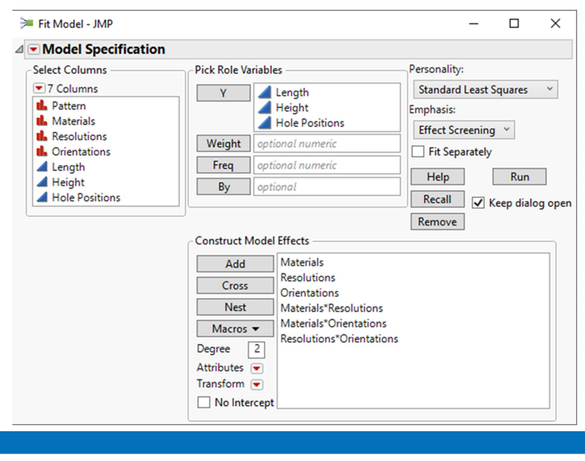
Keep constant factors	
Profile	Engineering
Infill density	30%
Infill pattern	Grid
Shell thickness	1.2 sides, 1.2 top and bottom
Support	Tree support, Touching build plate





Analyzing

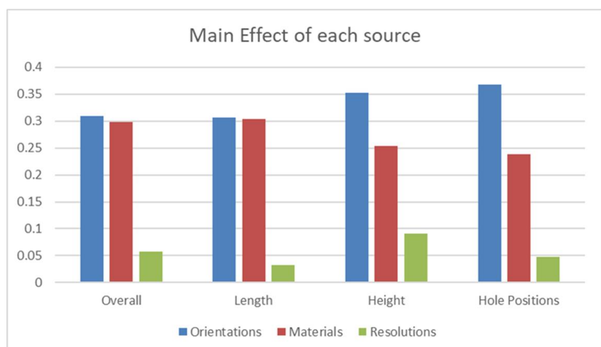
- Using PolyWorks and JMP

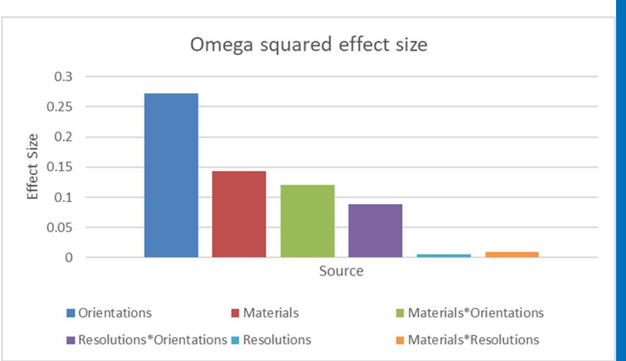


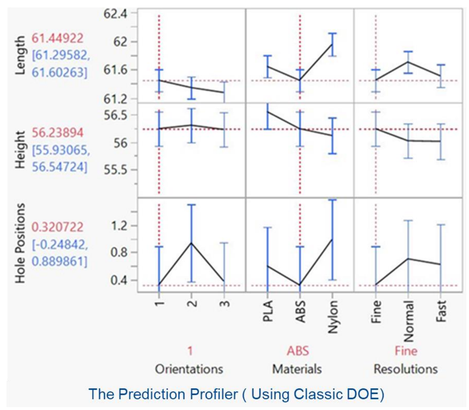
Results

Source	PValue
Orientations	0.00070
Materials	0.00129
Materials*Orientations	0.01579
Resolutions*Orientations	0.02709
Resolutions	0.03300
Materials*Resolutions	0.27265

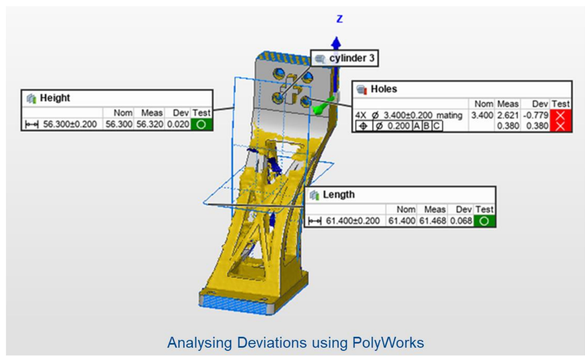
Source	Nparm	ω² Effect Size
Materials	2	0.1428
Resolutions	2	0.0063
Orientations	2	0.2727
Materials*Resolutions	4	0.0091
Materials*Orientations	4	0.1206
Resolutions*Orientations	4	0.0918







The Prediction Profiler (Using Classic DOE)



Analysing Deviations using PolyWorks

Conclusion

- Main Effect: Orientations > Materials > Resolutions
- Interaction Effect: Materials*Orientations > Resolutions*Orientations
- The desirable settings = ABS, Fine, Orientations 1

Recommendations

- Conduct **follow-up runs** and **confirmation tests** to validate initial findings
- Investigate the **properties and optimal environmental conditions** for the filaments used in printing
- Consider **material colour and scanner** to enhance measurement accuracy

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