

MICRO-SCALE CONCRETE 3D PRINTER

SHAP3

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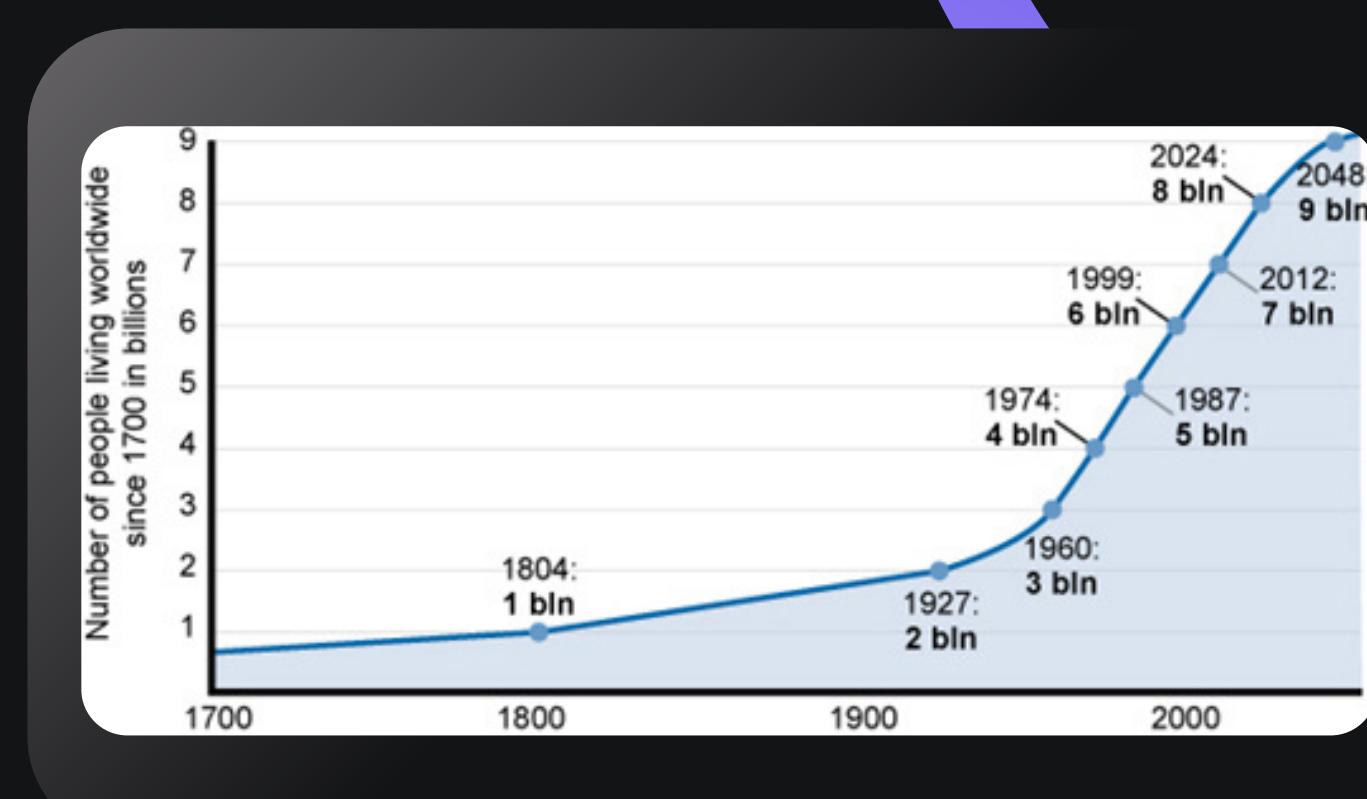
MR3002B

Mechatronic Systems Design and Implementation

CONTEXT OF DEVELOPMENT

- The graph continues into the future to a predicted global population in 2050 in excess of 9 billion.
- -----
- -----
- 0.8% Population Growth Rate in 2022

Land prices increased 60% from 2012-2019, and the cost of homes more than doubled from 1998 to 2021; for so, the US Department of Housing and Urban Development (HUD) leads housing efforts at the national level. This includes everything from mortgage programs to construction.



Project Relevance

Less Waste

Precise amount of material to be used in a structure, allowing up to 60% less waste on the construction site.

Less Time

Reduction of up to 70% of time; the project can be completed in just hours or days, depending on its magnitude.

More Security

The United States Occupational Safety and Health Administration (OSHA) reports that 1 out of 10 construction workers are injured each year. 3D printing may avoid this issue.

Aim

To bring cutting-edge technology closer to students, particularly those studying civil engineering at institutions like ITESM Campus Puebla.

By engaging directly with this innovative machinery, students not only gain hands-on experience but also become familiar with a technology that has far-reaching implications across various societal domains and the challenges of modern society .

State of Art & Technique

	Contour Crafting	Concrete Printing	D-Shape
Process	Extrusion	Extrusion	3D Printing
Use of mould	Yes (Become a part of component)	No	No
Binder	None	None	Chlorine-based liquid
Pros	- Smooth surface by trowel	- High strength - Minimum printing process	- High strength



COBOD - BOD 2



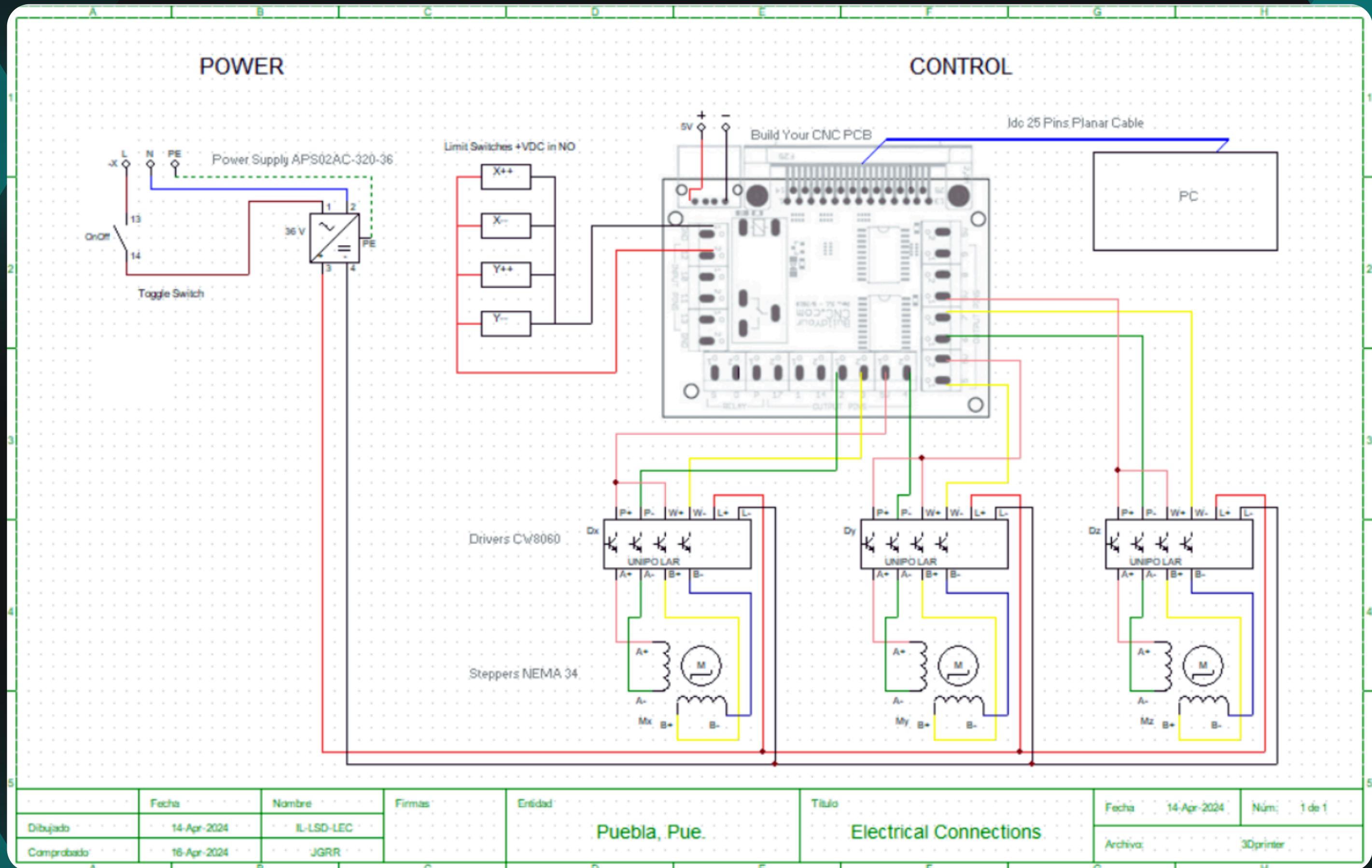
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Project Overview

Se introduce el diseño, prototipo e implementación de un sistema de impresión 3D en concreto de 2m x 2m x 2m, partiendo de componentes mecánicos existentes, componentes electrónicos reciclados de una máquina CNC, y otros materiales propuestos a comprar. El sistema está destinado a desarrollarse con un presupuesto relativamente bajo para ser replicado en instituciones educativas; se realizaron pruebas en el sistema logrando soportar un peso dinámico de 65 kg o más, un error inferior a 1 cm, movimiento simultáneo en múltiples ejes y un costo aproximado de 54,000.00 MXN.



ELECTRIC DIAGRAM

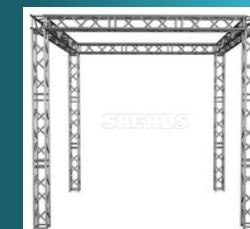
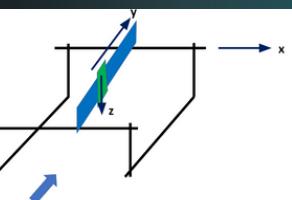


Structural Plan

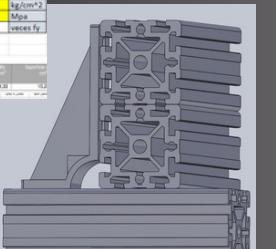
Stock revision and equipment familiarization

Imagen	Componente	Cantidad	Medidas	Descripción	Pieza en SolidWorks
	Cadena	4	2 m, 3.56 m, 2.64 m, 3.54 m	ejes x, y, z	<input checked="" type="checkbox"/>
	Rodamiento con guía	30	30 mm		<input type="checkbox"/>
	Rodamiento chicos	10	30 mm		<input type="checkbox"/>
					<input type="checkbox"/>

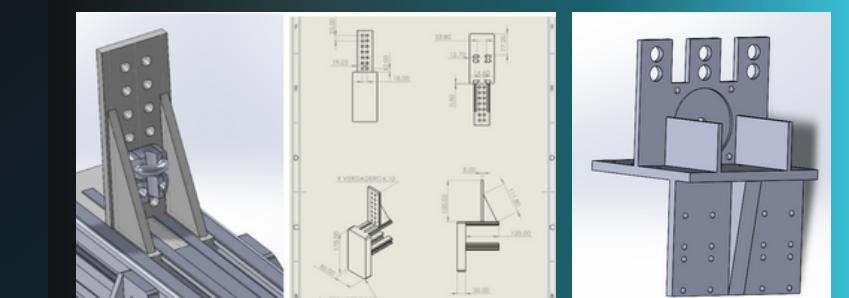
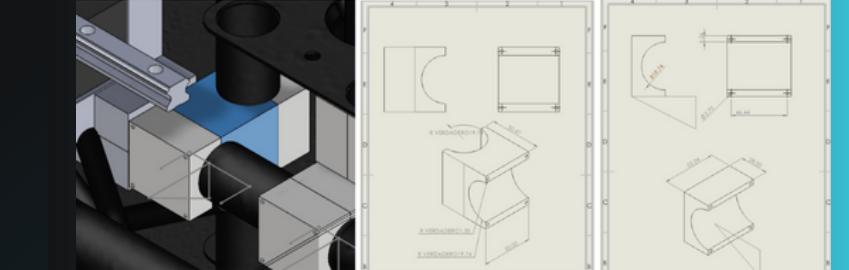
Fist concept



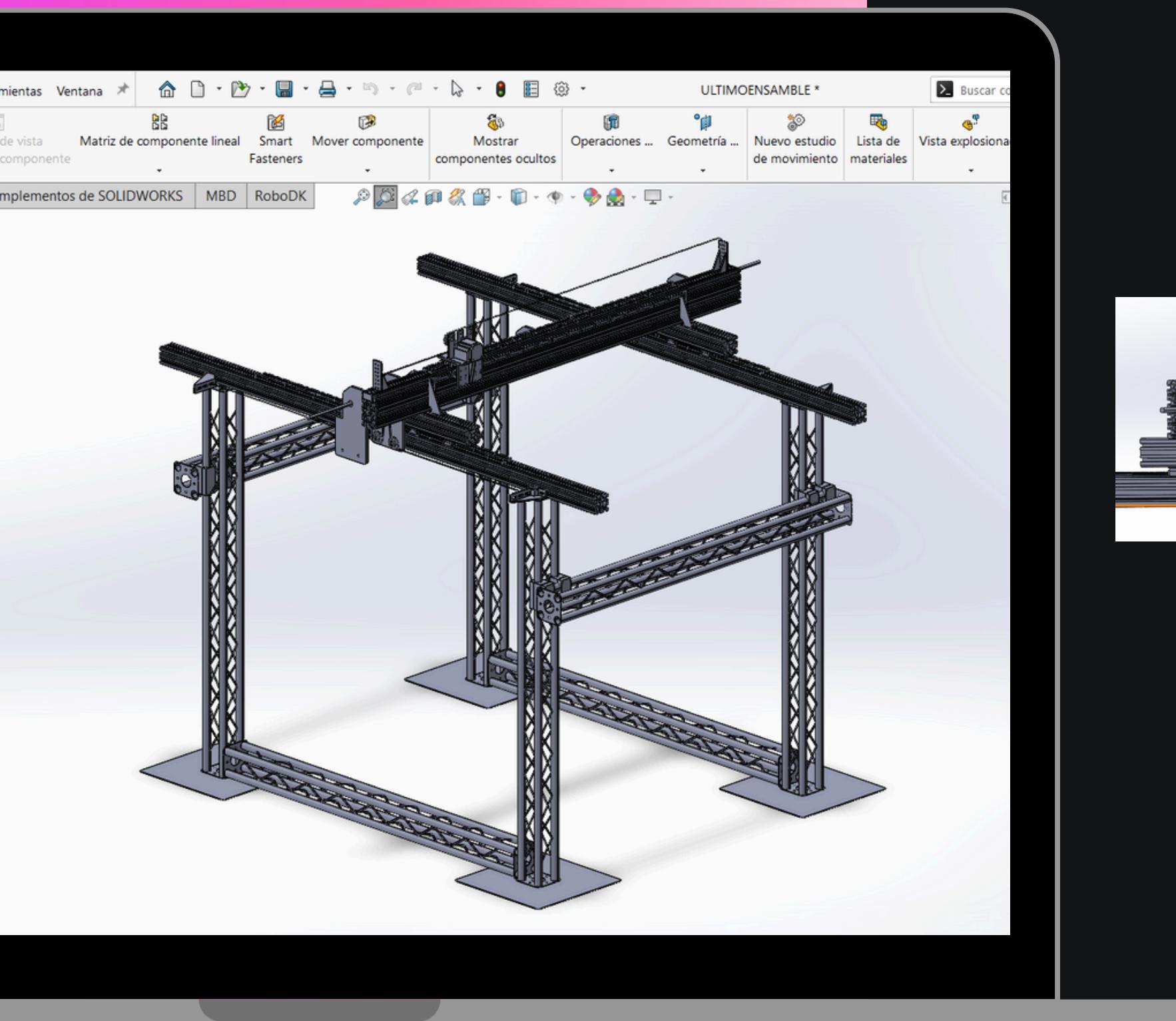
Structural Design



Design of accessories



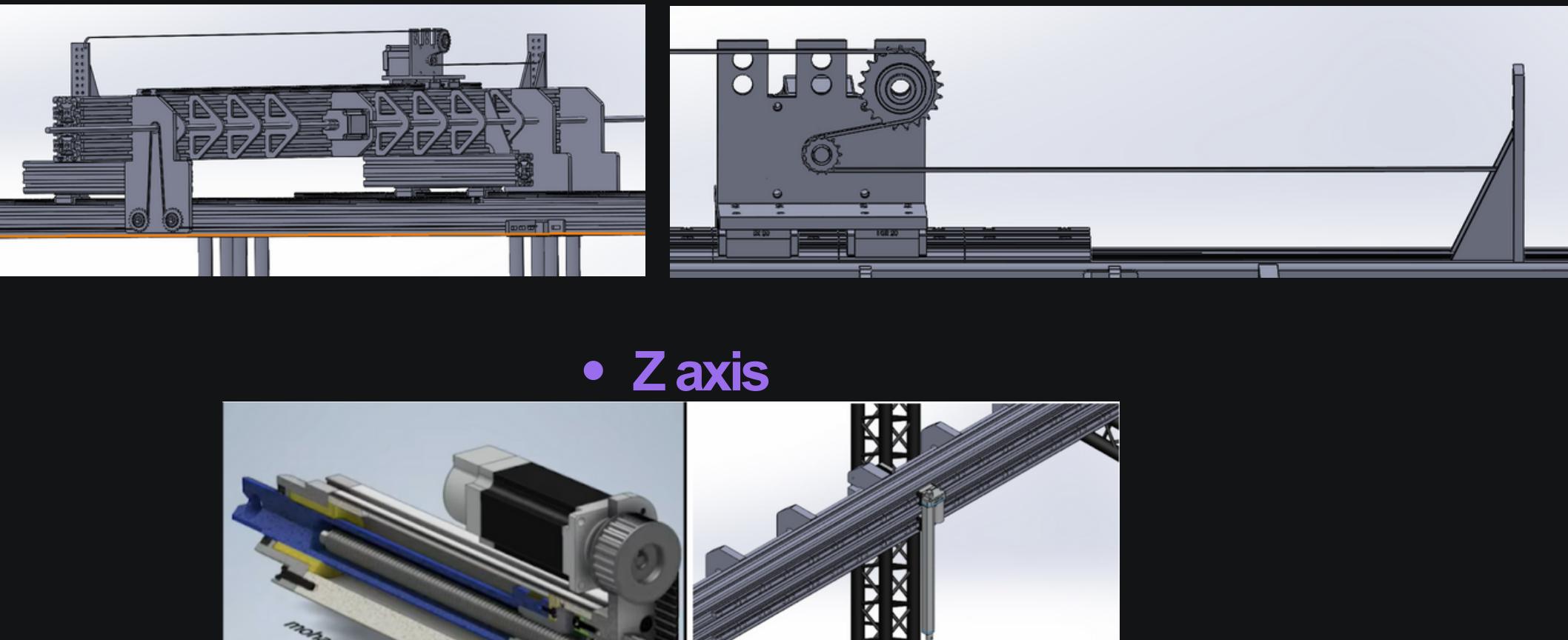
CAD prototype



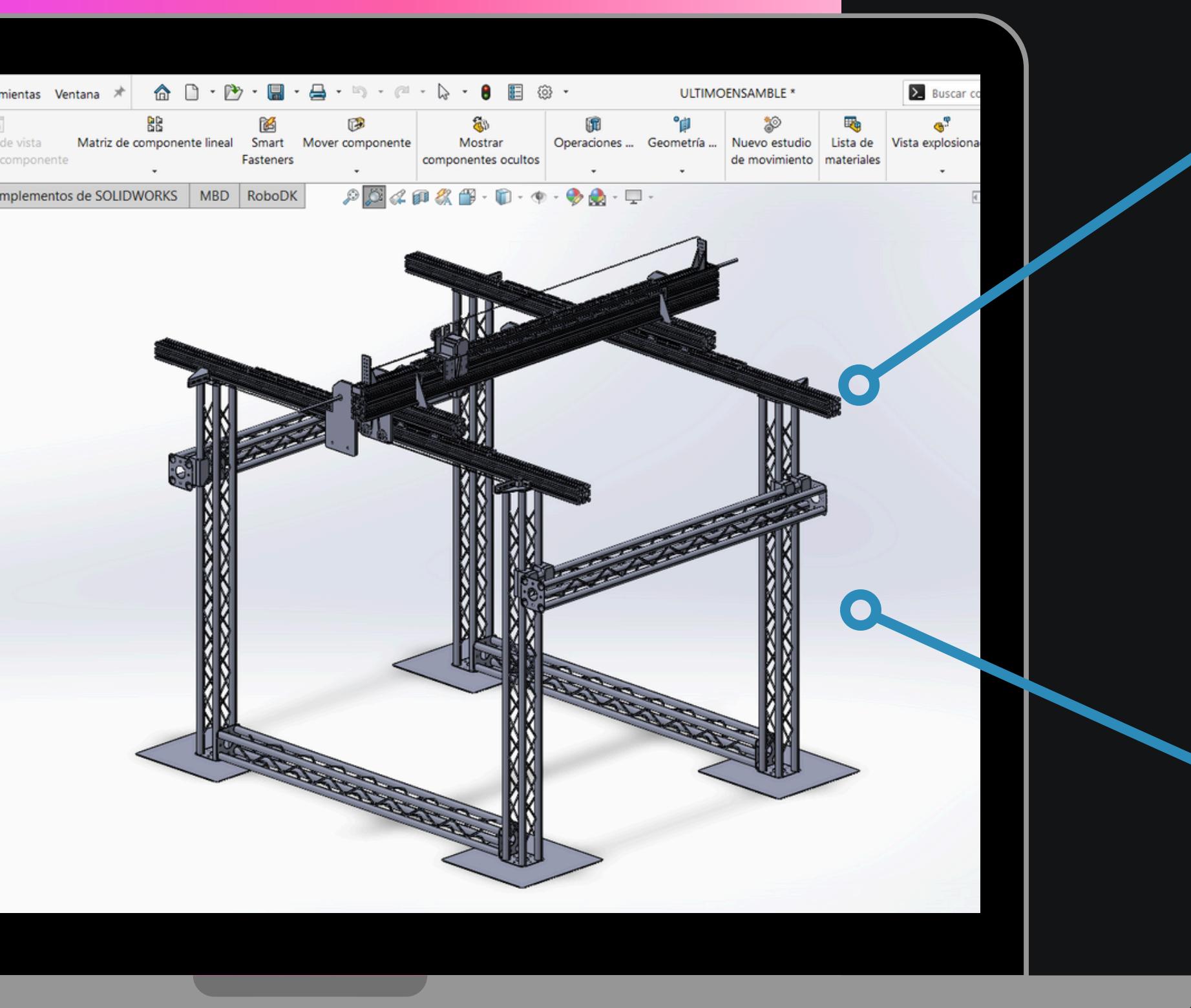
• X axis

• Y axis

• Z axis



FROM SIMULATION TO REALITY



System functioning



1

Hardware and software integration

2

“X” and “Y” axis moving simultaneously

3

Path following

Software configuration - Ports

Signal	Enabled	Step Pin#	Dir Pin#
X Axis	✓	4	5
Y Axis	✓	2	3
Z Axis	✗	6	7
A Axis	✗	5	9
B Axis	✗	0	0
C Axis	✗	0	0
Spindle	✗	0	0

Engine Configuration... Ports & Pins

Port Setup and Axis Selection | Motor Outputs | Input Signals | **Output Signals** | Encode

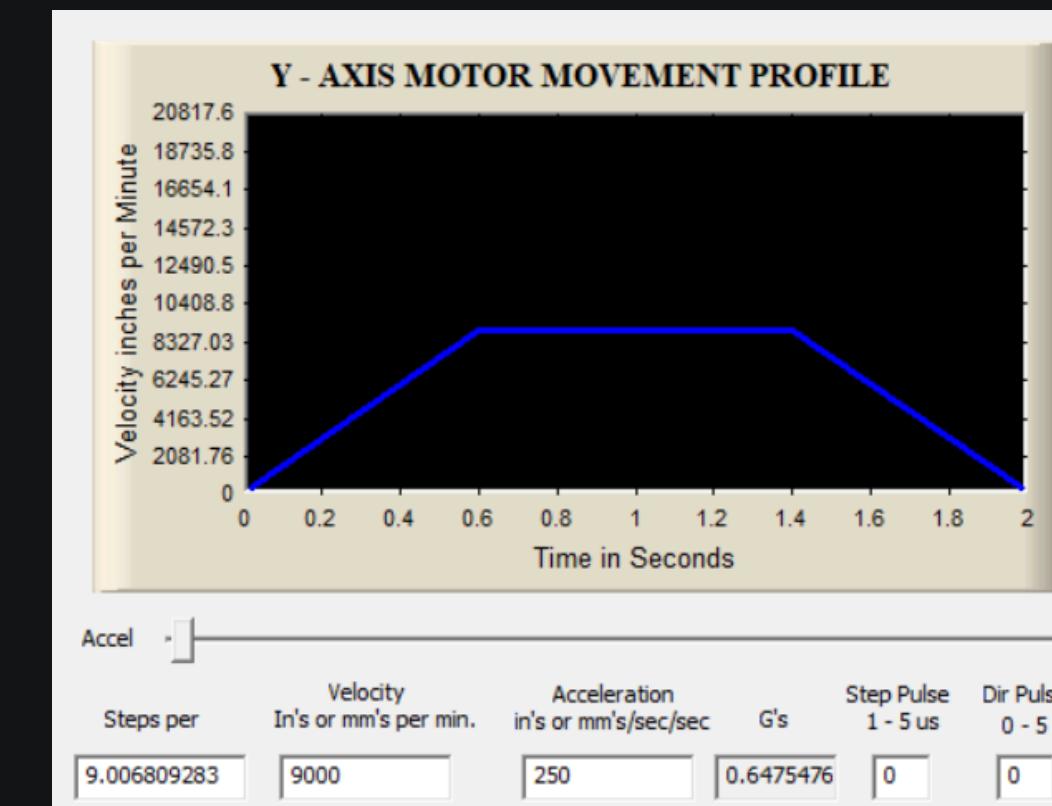
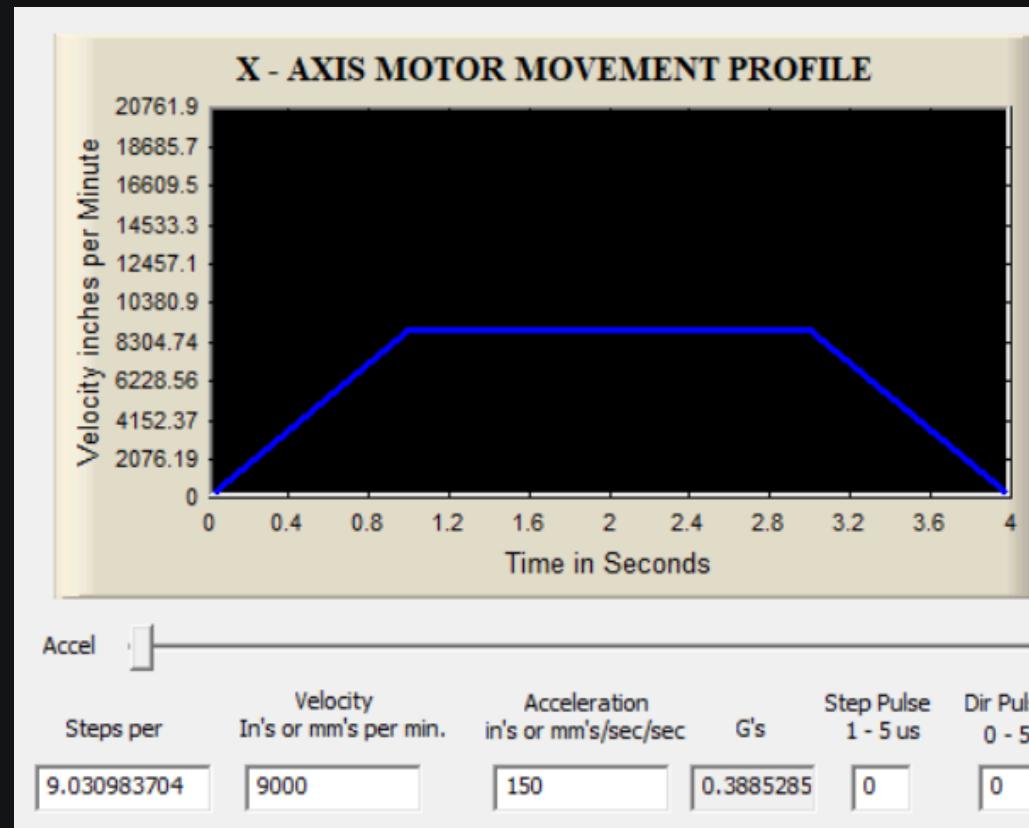
Signal	Enabled	Port #	Pin Number	Active Low
X ++	✓	1	12	✓
X --	✓	1	12	✓
X Home	✗	1	0	✗
Y ++	✓	1	12	✓
Y --	✓	1	12	✓

Entries are in setup units.

Axis	Reversed	Soft Max	Soft Min	Slow Zone	Home Off.
X	✗	1290	0	1.00	0.0000
Y	✗	1387	0	1.00	0.0000



Software configuration - Calibration



Axis Selection

Pick Axis to Calibrate

X Axis A Axis
 Y Axis B Axis
 Z Axis C Axis

OK

How far would you like to Move the X Axis?

100

OK

Set Steps Per Unit

X Axis Will be Set to 88.539055921569 Steps per Unit. Would you like to Accept it??

Yes No

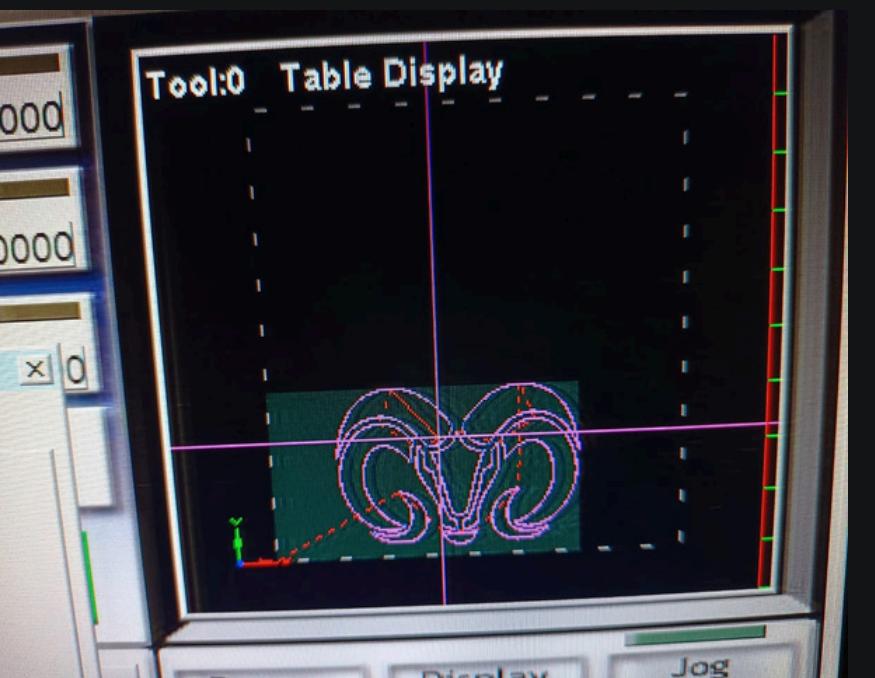
Path Following

Function Name	Description	Author
3dprinterAddon_2.2	MakerStorage 3D Printing Addon	Nuri Erginer

```
(Start cutting path id: path1)
(Change tool to Default tool)

G00 Z0.000000
G00 X385.695310 Y544.833984

G01 Z0.000000 F100.0(Penetrate)
G03 X339.493232 Y539.215527 Z0.000000 I0.118016 J-193.745736 F400.000000
G03 X302.133553 Y524.296892 Z0.000000 I34.829685 J-141.459424
G03 X270.352051 Y499.700226 Z0.000000 I71.248369 J-124.891318
G03 X242.847660 Y463.341800 Z0.000000 I131.732790 J-128.235573
G03 X224.664448 Y422.988884 Z0.000000 I192.068325 J-110.820060
G03 X210.607420 Y367.144530 Z0.000000 I355.847929 J-119.264702
G03 X206.134367 Y338.435906 Z0.000000 I939.937100 J-161.153146
G03 X205.691410 Y332.087890 Z0.000000 I45.265222 J-6.348016
G03 X205.984917 Y331.210788 Z0.000000 I1.457296 J0.000000
G03 X206.572270 Y330.917970 Z0.000000 I0.587353 J0.442665
G03 X207.191088 Y331.304223 Z0.000000 I0.000000 J0.688832
G03 X211.486330 Y340.968750 Z0.000000 I-129.949740 J63.540789
G02 X222.178667 Y366.225609 Z0.000000 I676.369495 J-271.445189
G02 X228.759770 Y379.722660 Z0.000000 I199.445592 J-88.895818
G02 X248.572701 Y409.718867 Z0.000000 I166.203098 J-88.238097
G02 X269.656951 Y430.275889 Z0.000000 I96.755967 J-78.146468
G02 X294.991537 Y444.963749 Z0.000000 I69.425007 J-90.555503
```



COSTS ANALYSIS

	Piece	Key	Extra	USD	Total USD	Total MXN
20	10 mm Flange Nut	3842345081	NA	0.25	5.00	85.35
20	M8 X 25 T-Bolt	3842528718	NA	0.97	97.00	1,655.92
8	90° Brackets 45/180 mm	3842551608	NA	22.79	182.38	3,113.46
2	90 X 90 mm Bosch Profile	3842553613	2 at 3m, 2 at 0.55 m	97.85	684.98	11,651.42
25	T- Nut M6	3842530285	NA	0.97	97.00	1,655.92
4	Guide VEVOR Rail	HSR 20	NA	107.40	429.60	7,159.34
8	2m 30X30 cm Perimeter Structure	NA	NA	NA	NA	18,240.00
4	Perimeter Structure Base	NA	NA	NA	NA	6,080.00
9	PLA Kg	NA	White	NA	NA	3,985.86

TOTAL MXN: \$53 627.27

*The presented quotation omits pre-existing materials on inventory, accessible lab tools, software licenses and general screwing material.**

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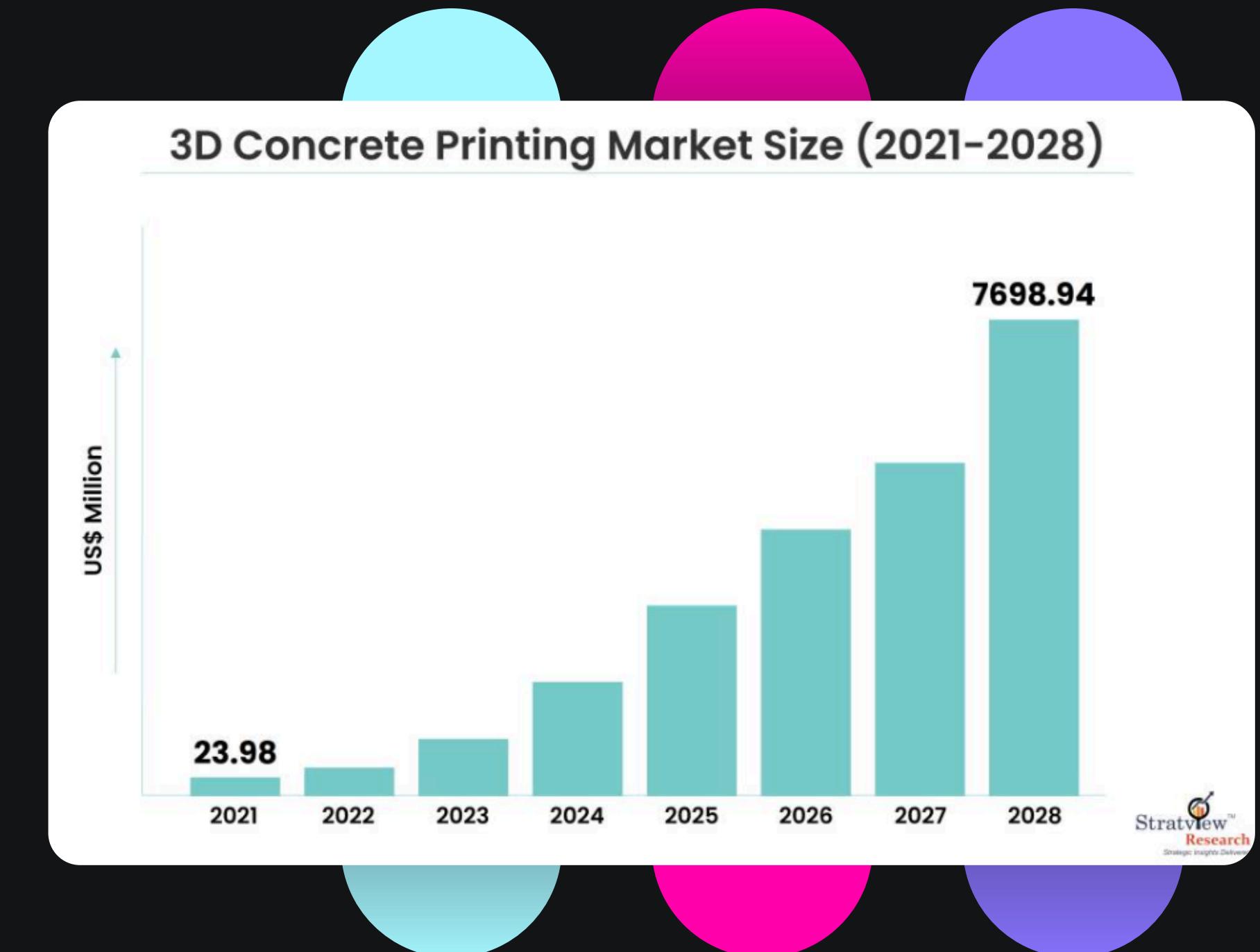
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Cost Comparison

Concrete is an economical material by itself, and therefore very popular in the sector. However, the concrete 3D printers themselves are quite expensive, with prices ranging from **\$180,000 to over \$1 million MXN.**

Concrete 3DP may present an **annual 15 percent market growth rate**, surpassing the market value of 56.4 million dollars by 2021



MAIN CHALLENGES AND LIMITATIONS

Material Delivery

Calculated for the 4th week, however received on the 7th.

CAD models and design tasks were parallelly developed to avoid retard.

Distance Work

Mexico - China collaboration for project development.

Z axis mechanism

Theoretically designed and not implemented due to time and spatial limitations.

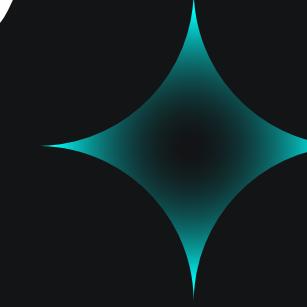
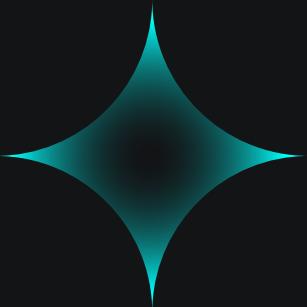
Developing periods shortage

Time shortages let not remaining time for proposed tasks such as tri-dimensional movement and nozzles development

Further work

- The modernization of the used hardware (PC, monitor and mouse).
- The exploration of open-source control software such as Linux CNC.
- The exchange of MDF pieces for the originally established PLA 3D printed pieces.
- The exploration of Z-Axis non-invasive movement mechanisms.
- The integration of high precision sensors for redundancy to determine position and other relevant variables.
- The integration of this system to a pre-mixing and a feeding system.
- The analysis of different concrete compositions to achieve optimal results.
- The distance-monitoring of the system on interfaces through tools such as MQTT protocol, Micro-controllers and Cloud Services.

THANK YOU



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