

# COBOD Training L1

Module 1.3

## Printer parts and installation.

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## **AGENDA AND OBJECTIVES**

1. DOCUMENTS SUPPORTING THIS PRESENTATION (2 MIN)
2. SYSTEM OVERVIEW (45 MIN)
3. ROLES AND RESPONSIBILITIES (10 MIN)
4. KPI'S AND GENERAL 3DCP TERMINOLOGY (15 MIN)
5. SITE PREPARATIONS (10 MIN)
6. PRINTER INSTALLATION (20 MIN)
7. SAT (SITE ACCEPTANCE TEST) (10 MIN)
8. PRINTING PROCESS OVERVIEW (15 MIN)
9. TRAINING AND SUPPORT (10 MIN)
10. CERTIFICATION TEST AND FEEDBACK (30 MIN)

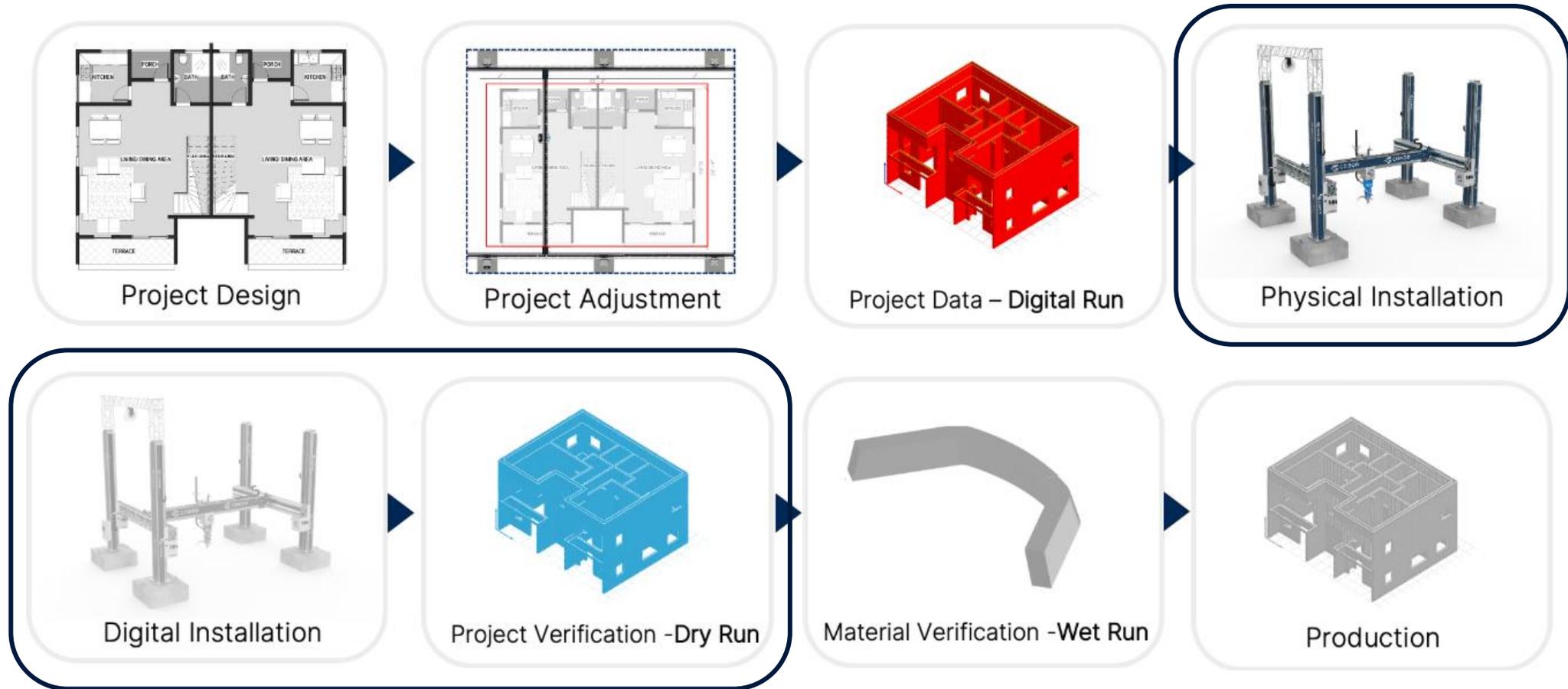
# DOCUMENTATION THAT SUPPORT THIS MODULE

1. WELCOME LETTER
2. BOD2 PRINTER OPERATIONS MANUAL + BOD2 USER INSTRUCTIONS = SOP

Documents and links:  
[www.cobod.com/configurator/](http://www.cobod.com/configurator/)

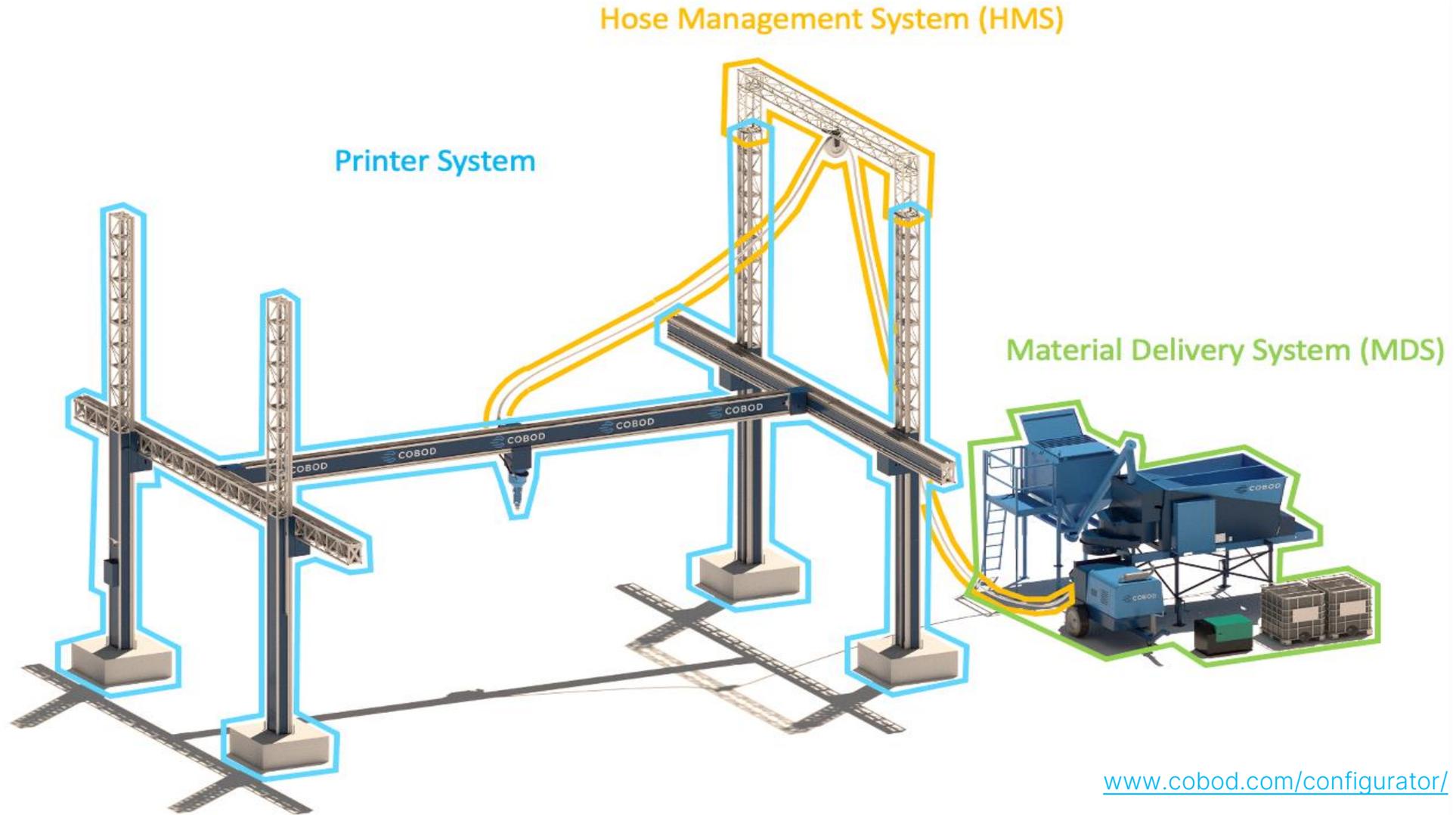


# DESIGNING IN THE OVERALL 3DCP PROCESS DIAGRAM



# SYSTEM OVERVIEW

BOD2



[www.cobod.com/configurator/](http://www.cobod.com/configurator/)

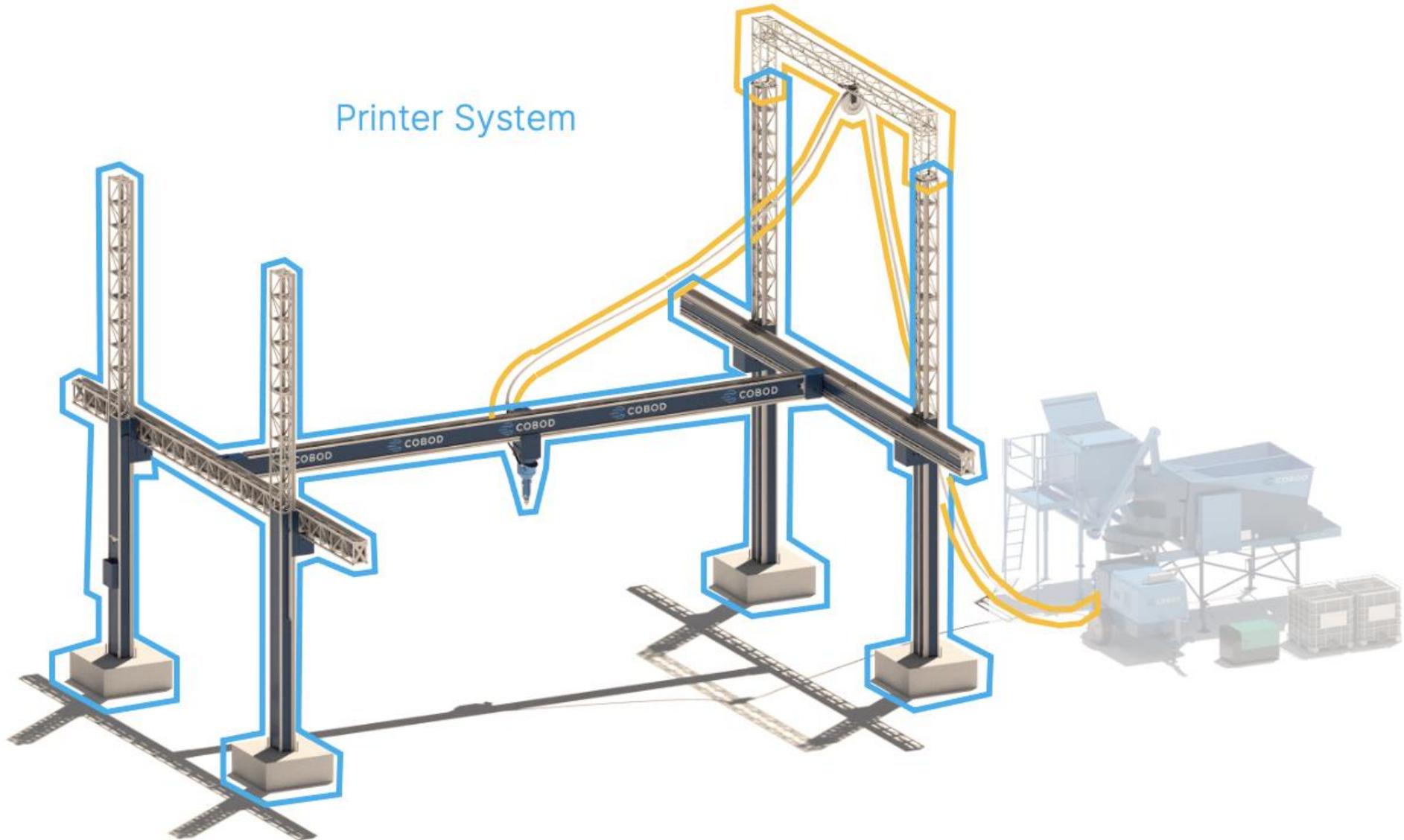


# AREA OF INTEREST

BOD2

## Hose Management System (HMS)

Printer System



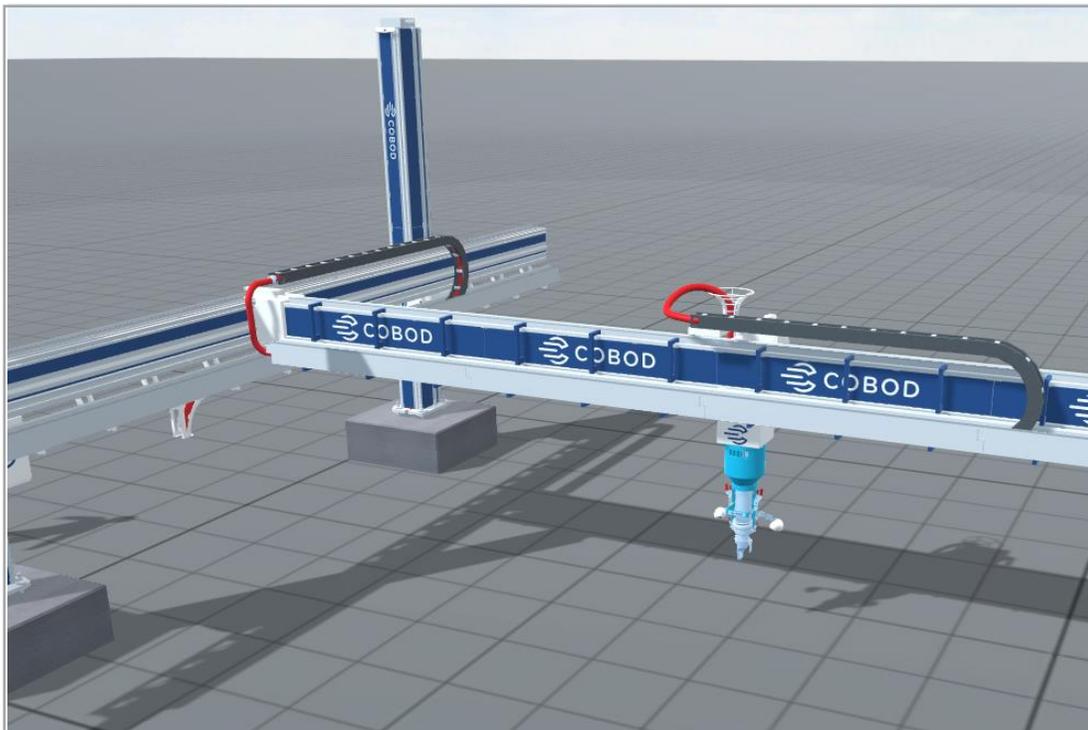
# HOSE MANAGEMENT SYSTEM

TWO OPTIONS

1. Recommended for large machines (above 4-4-4)

## Advanced Hose Management System (AHMS)

Main parts: Hose type (color and dimensions), modular e-chain, modular trays, connectors and safety pins.



2. Recommended for small machines (up to 4-4-4)

## Hose Management System (HMS)

Main parts: Hose type (color and dimensions), pulley, Allu trusses, crane, connectors and safety pins.



# **PRINTER SYSTEM COMPONENTS**

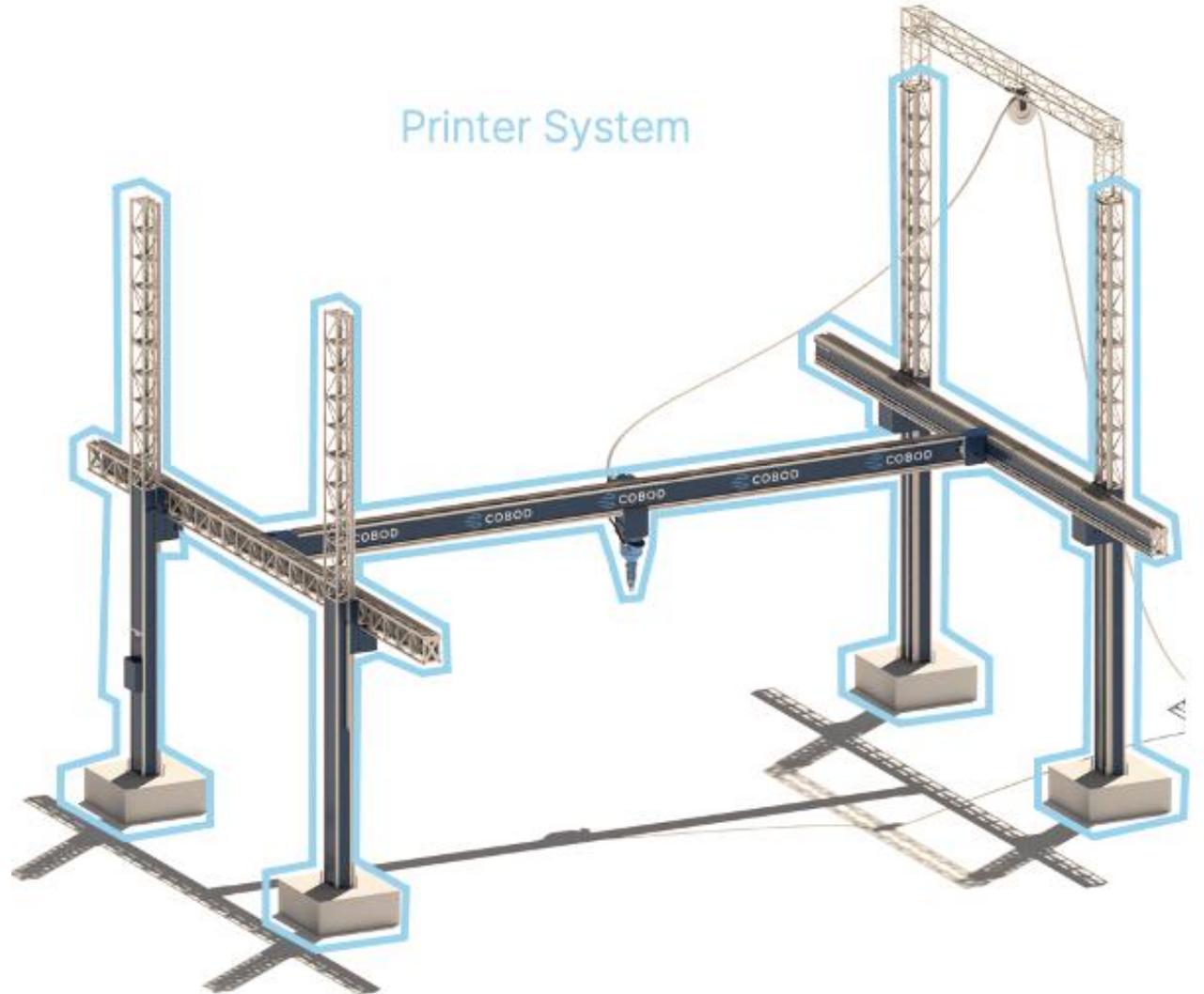
BOD2

## Physical

- ▶ Mechanical
- ▶ Electrical

## Digital

- ▶ Duet
- ▶ Omron



# MECHANICAL

PHYSICAL PRINTER

# MODULES AND AXES

## BOD2

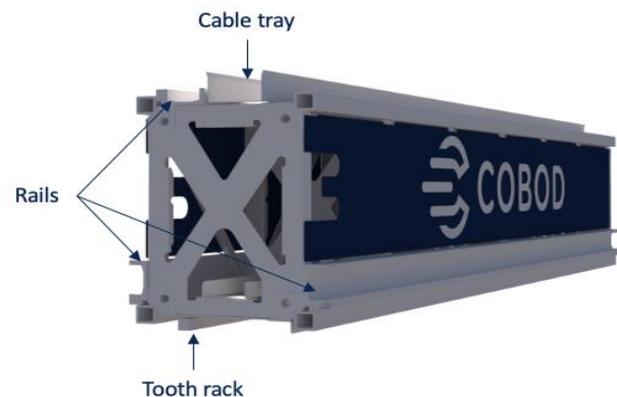
The printer flexibility and adaptability mainly resides in the fact that it is highly modular.

The same type of modules assembled create a beam and beams create axes.

The printer's name indicates size configuration: A BOD2, 2-3-4 will have 2 X-modules, 3 Y-modules and 4 Z-modules on each axis.

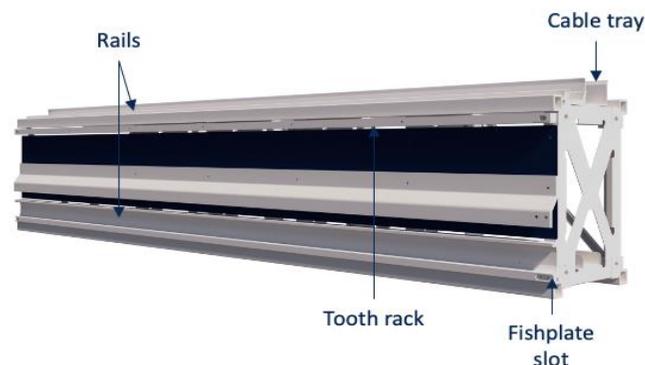
Modules are 2.525 m long each and are connected by 4x m16 bolts between each module. Any printer can be made in a smaller configuration by simply removing modules and rolling up the additional cable.

### X MODULE



- ▶ X axes are assembled of 2-5 X modules.
- ▶ To increase the size of an X or Y beam, extended cables must be purchased.
- ▶ Company logos are typically displayed in these modules.

### Y MODULE



- ▶ Y axes are assembled from 2-12 Y modules.
- ▶ It is important to store Y beams correctly to prevent damage in the cable trays and rails.
- ▶ Y axes have small tooth racks.

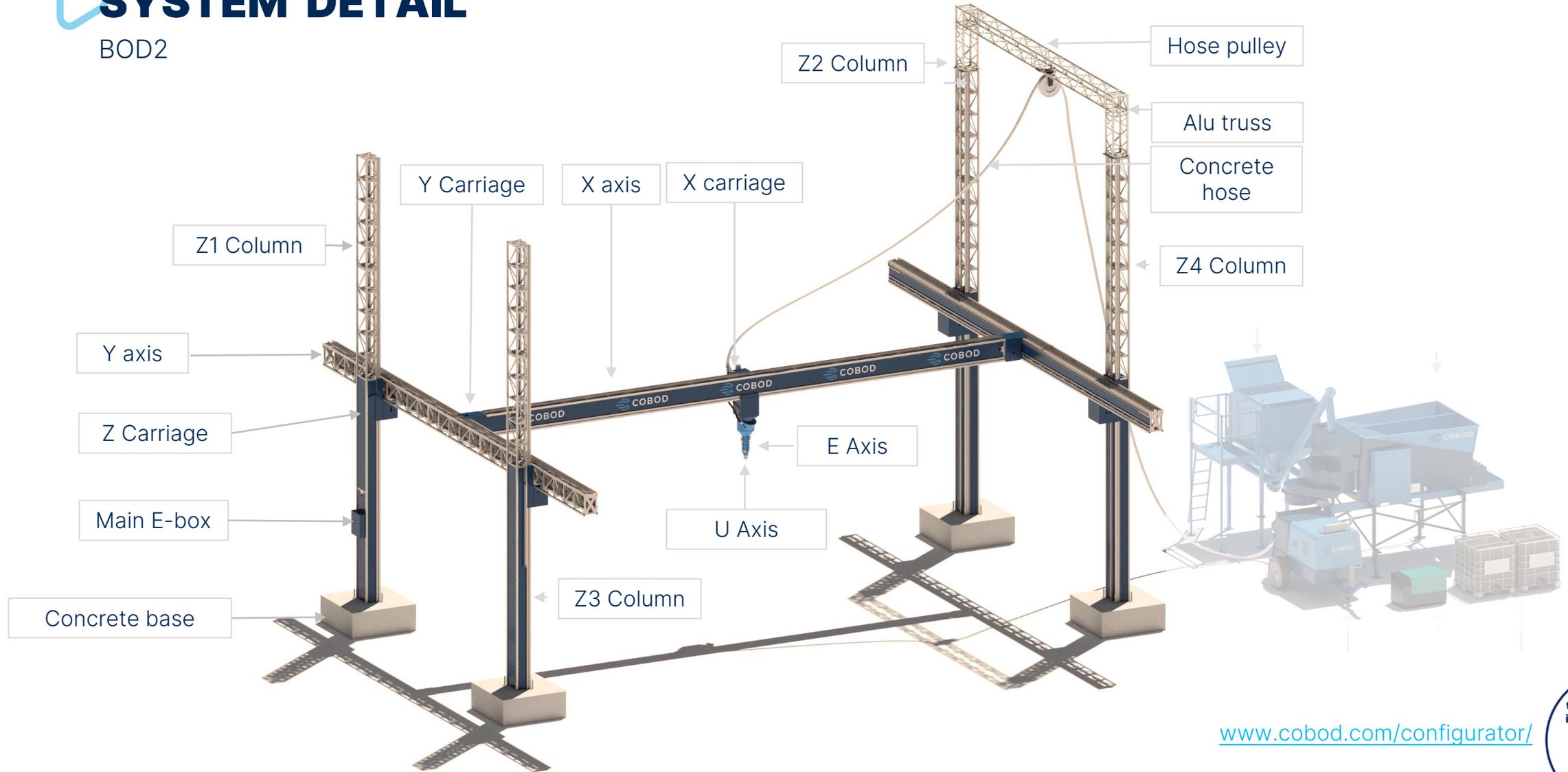
### Z MODULE



- ▶ Z axes are assembled from 2-4 modules.
- ▶ Z axes can be built larger without adding cable.
- ▶ Z axes are identifiable upon arrival by the lower plate and upper hook.
- ▶ Z axes have large tooth racks.

# SYSTEM DETAIL

BOD2



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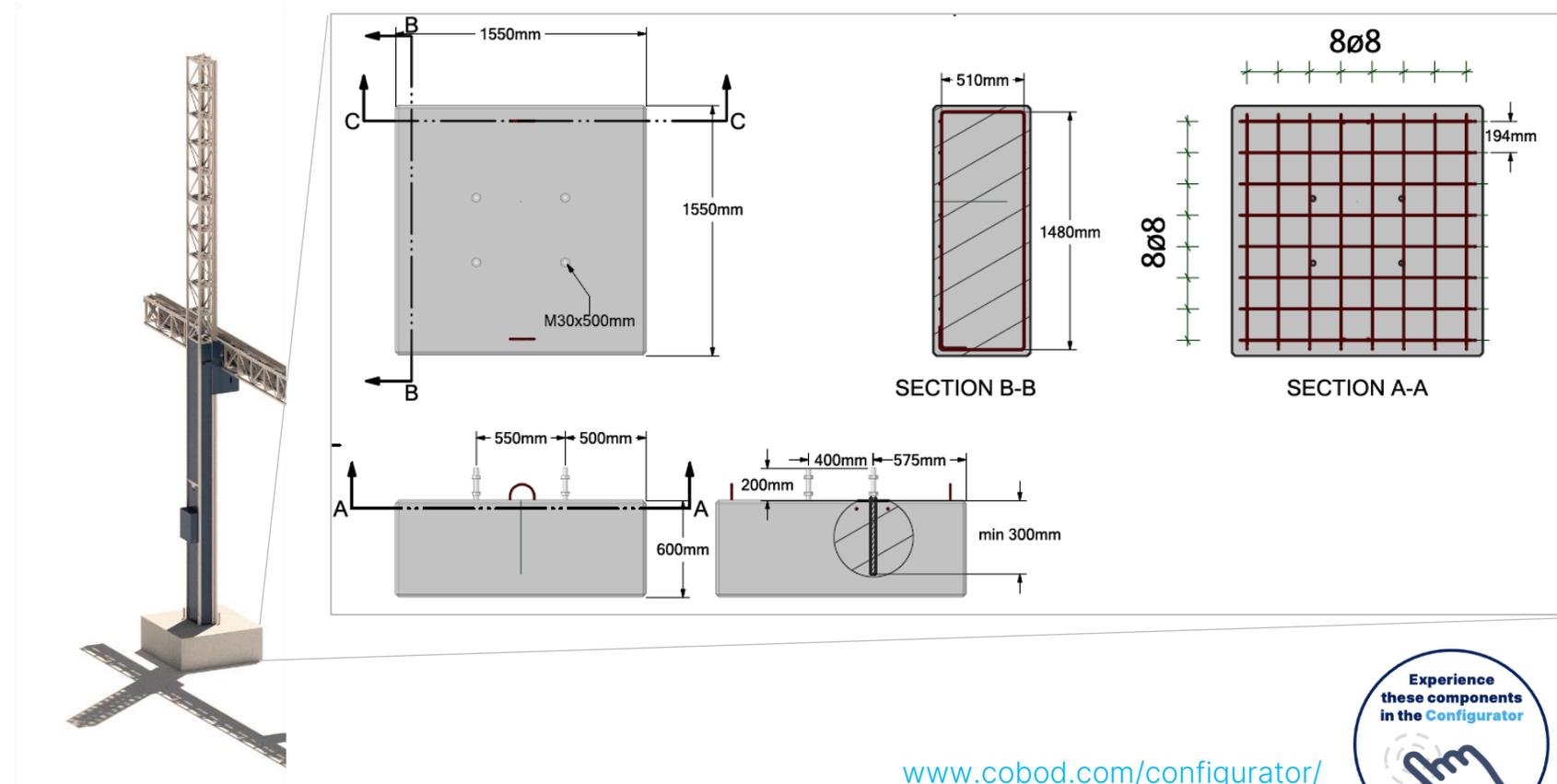


# CONCRETE FOUNDATION BLOCKS FOR 3D PRINTER

BOD2

Used for mounting the printer on site and/or as a strategy to gain extra height.

- ▶ Weighs 3 Metric Tonnes each.
- ▶ We recommend to produce locally to prevent shipping extra cost.
- ▶ An additional set of feet can be produced to decrease installation time.
- ▶ Production drawings are provided by COBOD at the COBOD Library.
- ▶ Feet can be made higher than 600mm, but it will require an extension nozzle to reach the base. Extensions up to 600mm has been tested to work.



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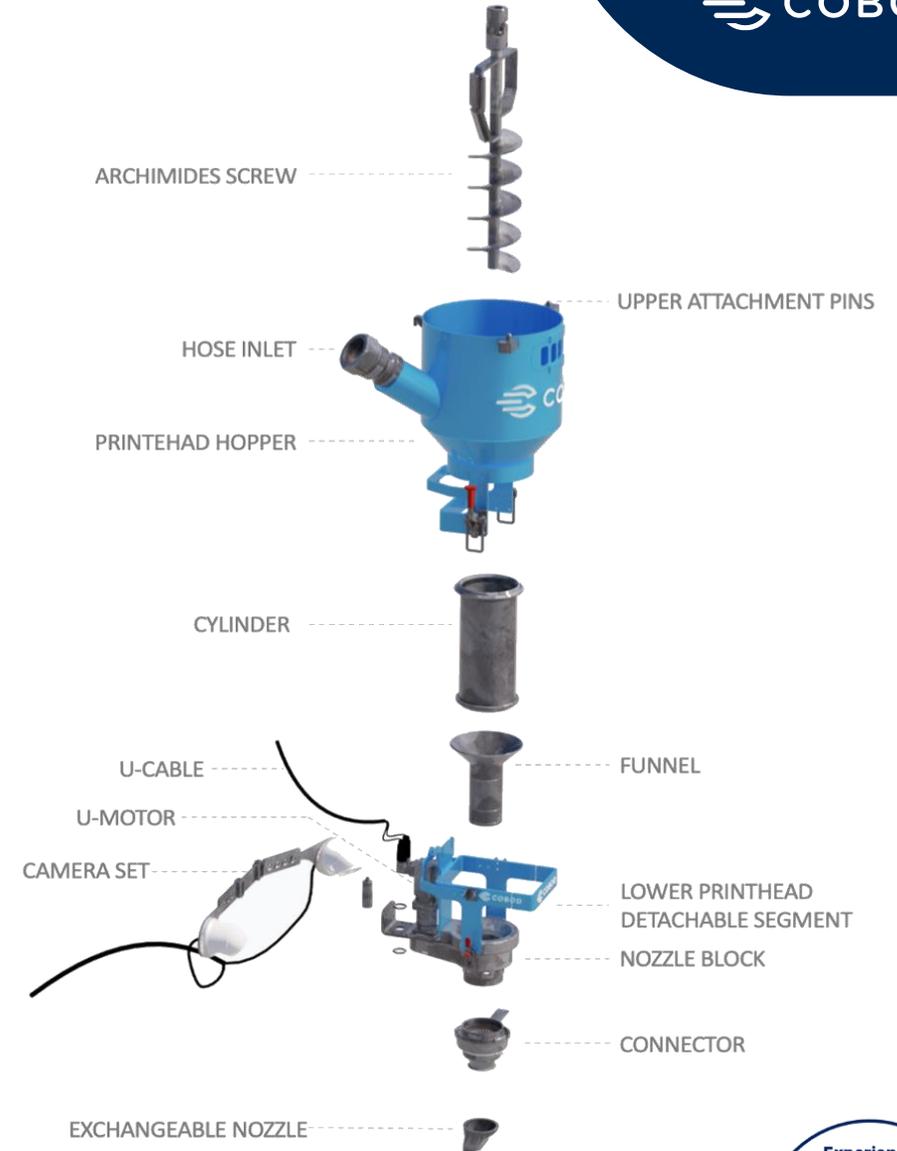


# PRINT HEAD

## BOD2

The print head (also known as the “extruder” in plastic desktop printers) is mounted on the X carriage and is the most visible component of the construction printer. It is highly modular and has direct contact with concrete. It is essential to learn all its part names, handling procedures and proper maintenance.

- ▶ The print head is mounted each day before printing and taken off after each operational day for cleaning.
- ▶ A dedicated print head stand comes with the machine, the stand serves as the unloading dock for cleaning.
- ▶ Cameras can be removed each day to protect from theft.
- ▶ The lower part of the print head usually gets covered with concrete and to prevent damage to functionality, it is recommended to perform daily, weekly and monthly cleaning and maintenance



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# **ELECTRICAL**

PHYSICAL PRINTER

# CABLES AND CONNECTORS

## BOD2

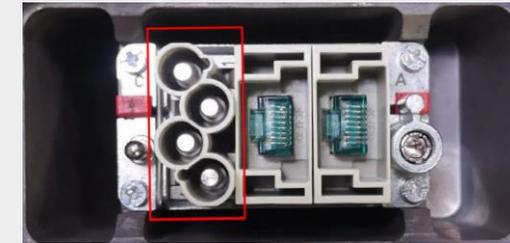
Cables and connectors are vital for all internal and external communication in the printer.

Their correct identification, installation, and general care is also important for safety and maintenance.

Avoid cables in wet areas and prevent tripping hazards or hanging electronics with the correct use of protective cable covers and best business practices.

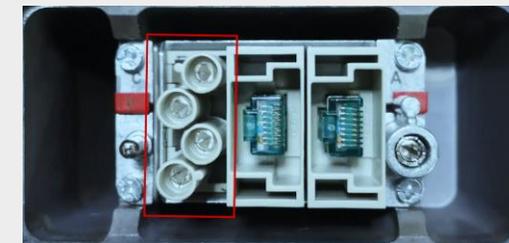
- ▶ **Internal cables:** all cables used to connect printer parts together.
  - E-chains are used for all moving parts.
  - Power and signal cables run in the same harness.
  - Two ethernet cables run to all carriages, one is reserved for PLC (EtherCAD) one is used for AUX components like cameras.
  - Dedicated GND / PE cable.
- ▶ **External cables:** all cables connecting to external components.
  - All connections to the bottom of the E-box.
  - Power plug (provided from COBOD).

Male connector



INPUT PLUGS ARE ALWAYS MALE

Female connector

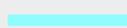
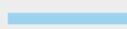
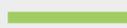
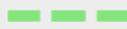


OUTPUT PLUGS ARE ALWAYS FEMALE

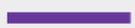
# ELECTRICAL

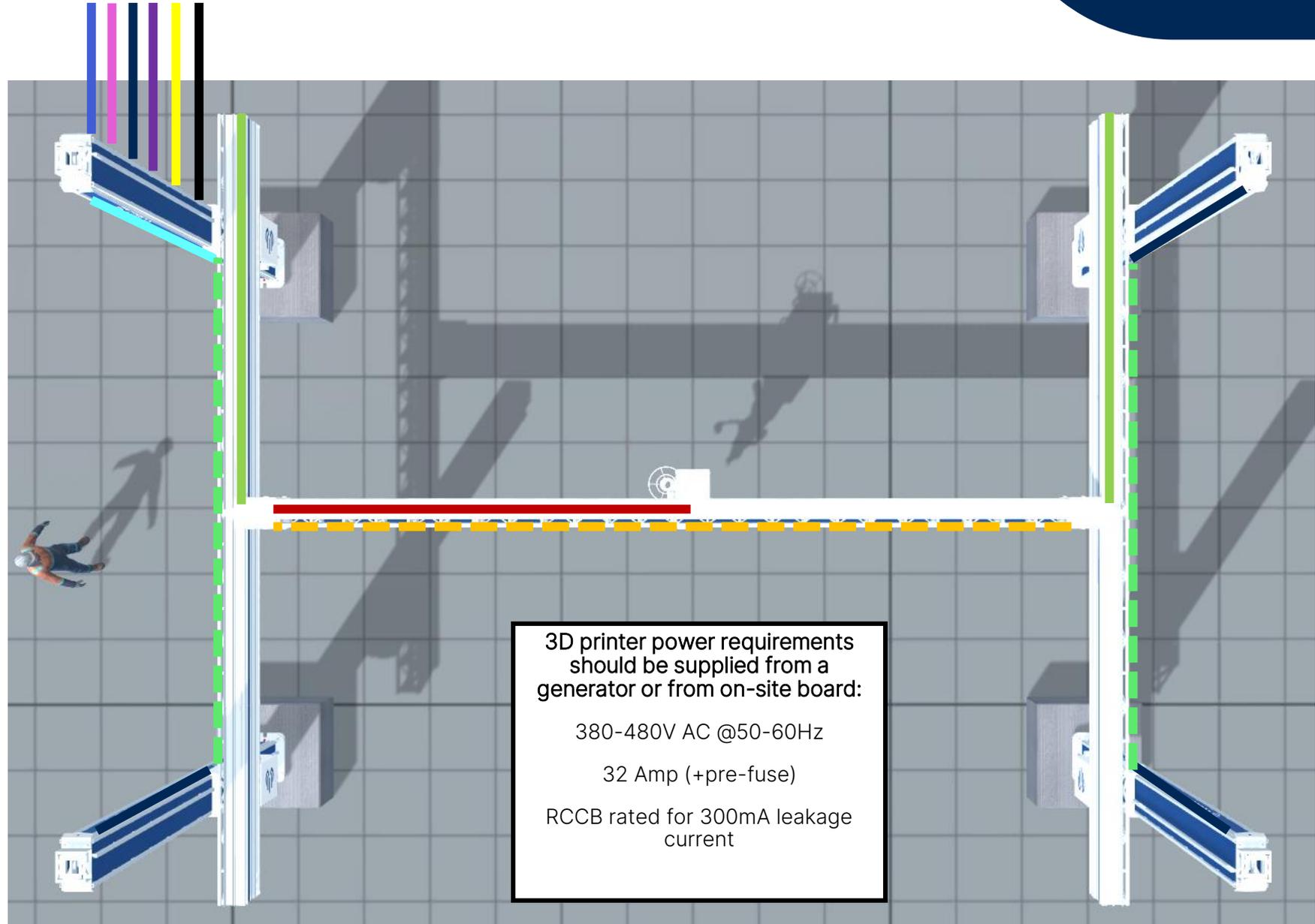
## CONNECTION SCHEME

### Internal cables

-  EB-Z1 cable (E-chain)
-  Z-Estop cable (E-chain)
-  Z-Y cable (E-chain)
-  Z-Z cable (Inside truss)
-  Y-X cable (E-chain)
-  Y-Y cable (inside truss)

### External connections (E-box)

-  Input power
-  Operator remote (safety)
-  Pump control
-  Ethernet
-  Dosing system
-  Wifi + LTE Antenna



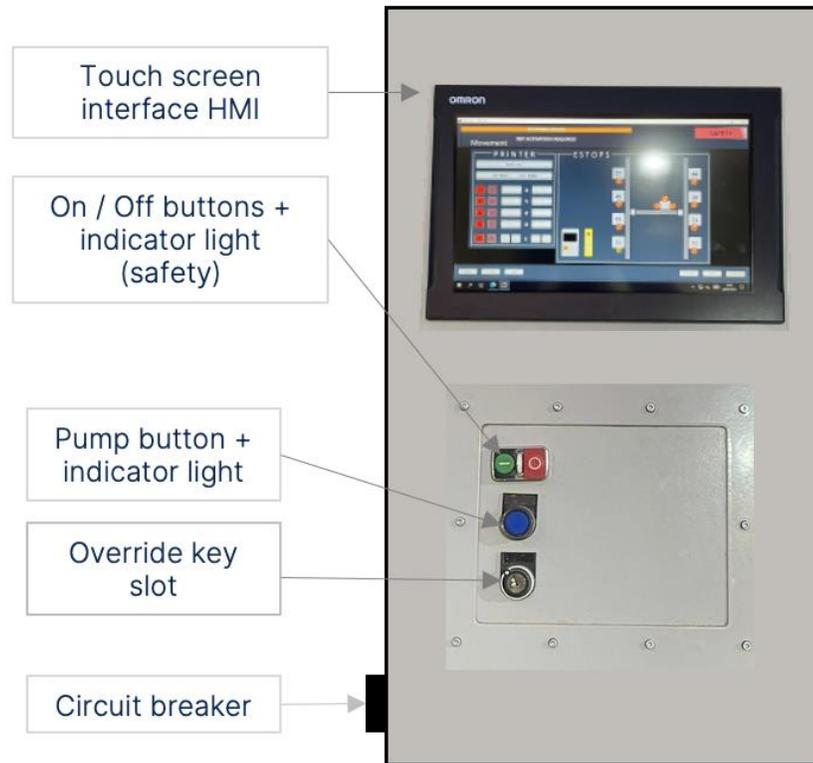
# MAIN E-BOX

BOD2

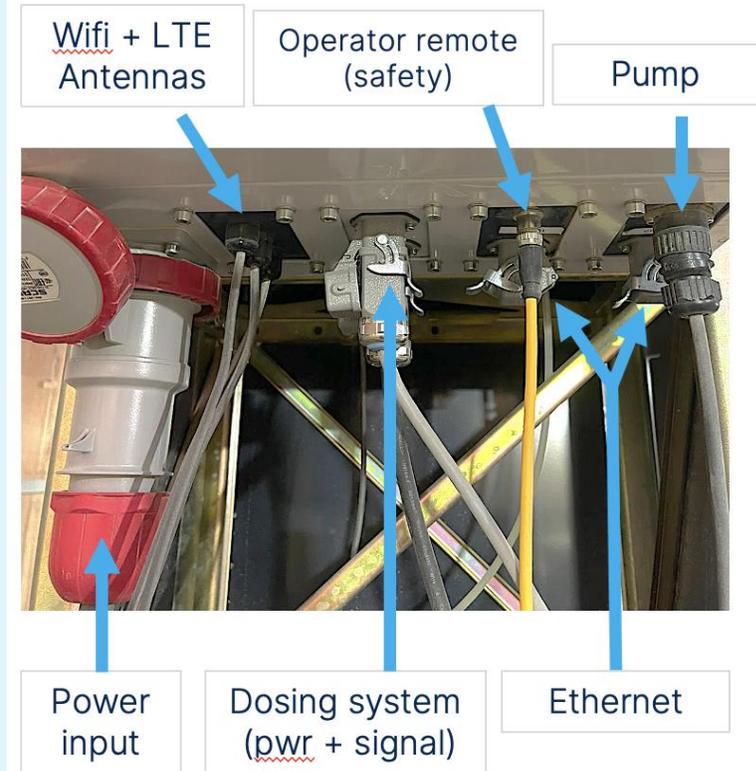
## LOCATION



## INTERFACE



## CONNECTIONS



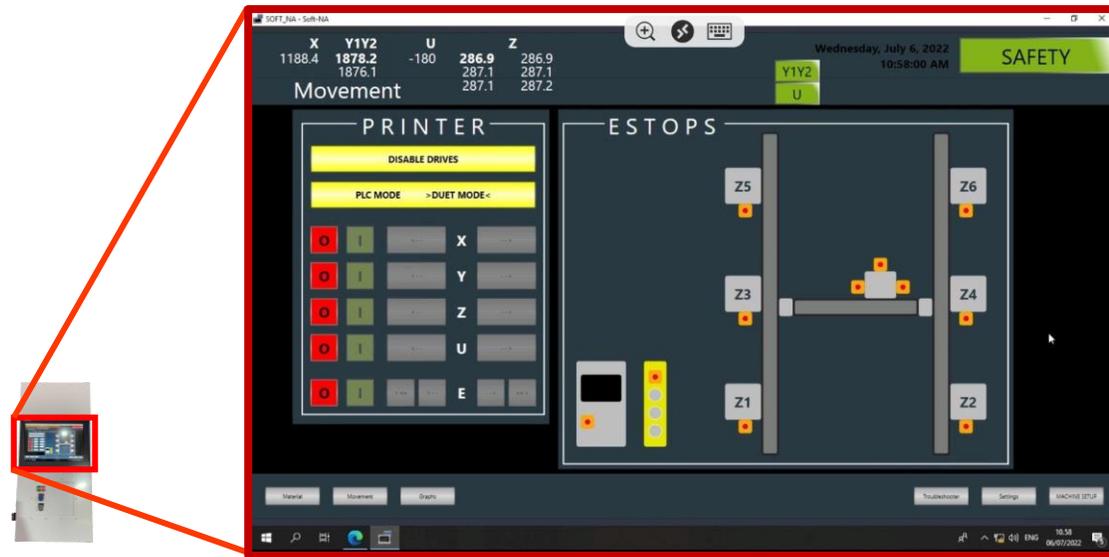
# **SOFTWARE INTERFACES**

DIGITAL PRINTER

# INTERFACES

BOD2

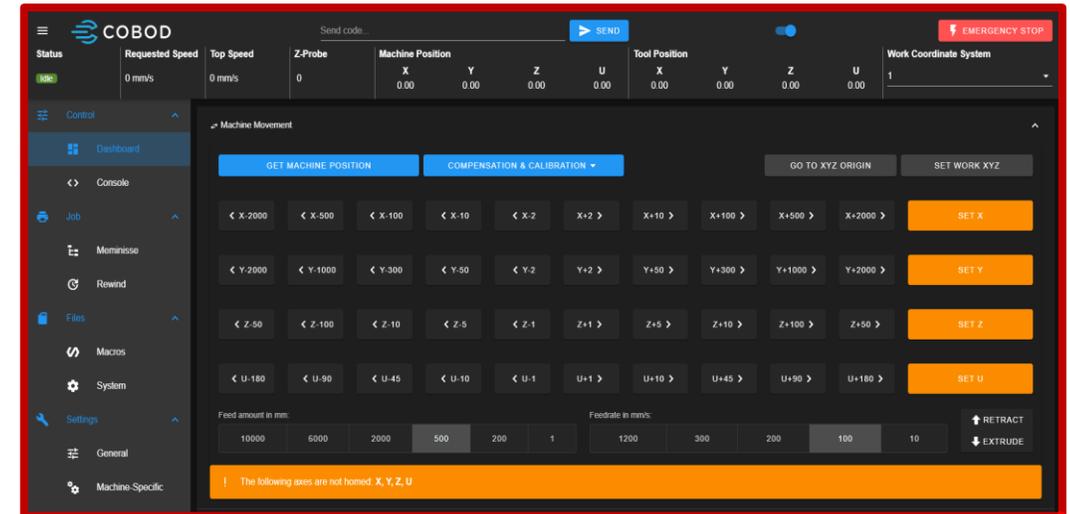
## OMRON-SOFTNA



Z1 E-BOX

- ▶ SoftNA is the interface to the Omron PLC system.
- ▶ SoftNA is accessed through the touch screen located on the main E-box.
- ▶ SoftNA can be accessed remotely as well for i.e. remote support.
- ▶ SoftNA is used for start up, calibration and for general troubleshooting.

## DUET



LAPTOP

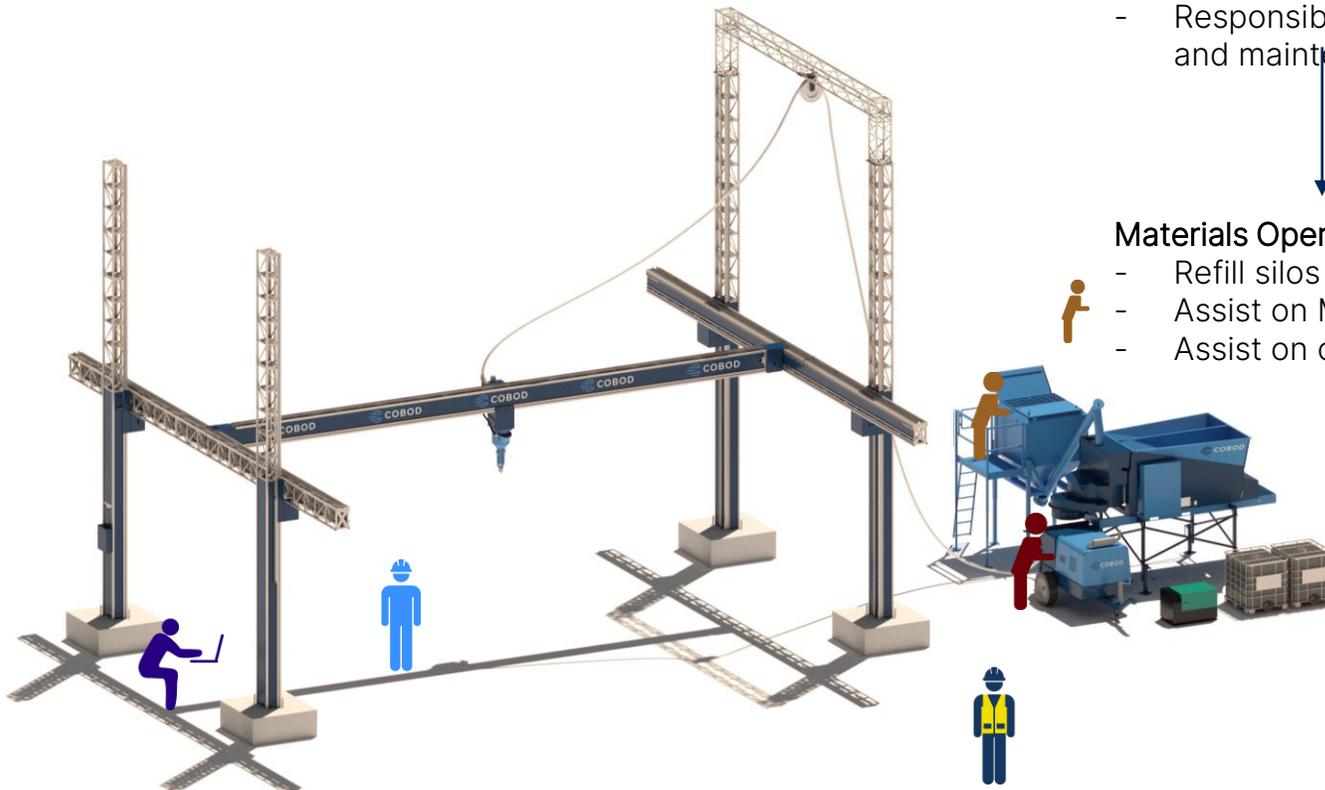
- ▶ Our proprietary DUET program is accessed through a web browser like Chrome or Edge.
- ▶ When connected to the printer (either through wifi or ethernet) the IP address is typed in the address field: 192.168.1.2.
- ▶ DUET is used for uploading printing files from the COBOD Slice program, and for all standard operations of the printer during printing.
- ▶ More information on the DUET functionality is provided in L2.
- ▶ Windows based systems recommended

# INSTALLATION AND LOGISTICS

PRINTING SITE

# ROLES AND RESPONSIBILITIES

## ON-SITE LABOUR DIVISION



### Site Manager (SM)



- Manage planning, scheduling and logistics
- Coordinate with external suppliers
- Day-to-day site management

### Materials Operator (MO)



- Batching of concrete
- Quality Assurance
- Responsible for installation of MDS
- Responsible for MDS cleaning and maintenance

### Printer Operator (PO)



- Operation of printer
- Prepare print files (slicing)
- Responsible for verification of CAD models
- Responsible for installation of printer
- Responsible for printer cleaning and maintenance

### Materials Operator Assistant (MOA)



- Refill silos with cement and aggregates
- Assist on MDS setup
- Assist on cleaning and maintenance

### Printer Operator Assistant (POA)



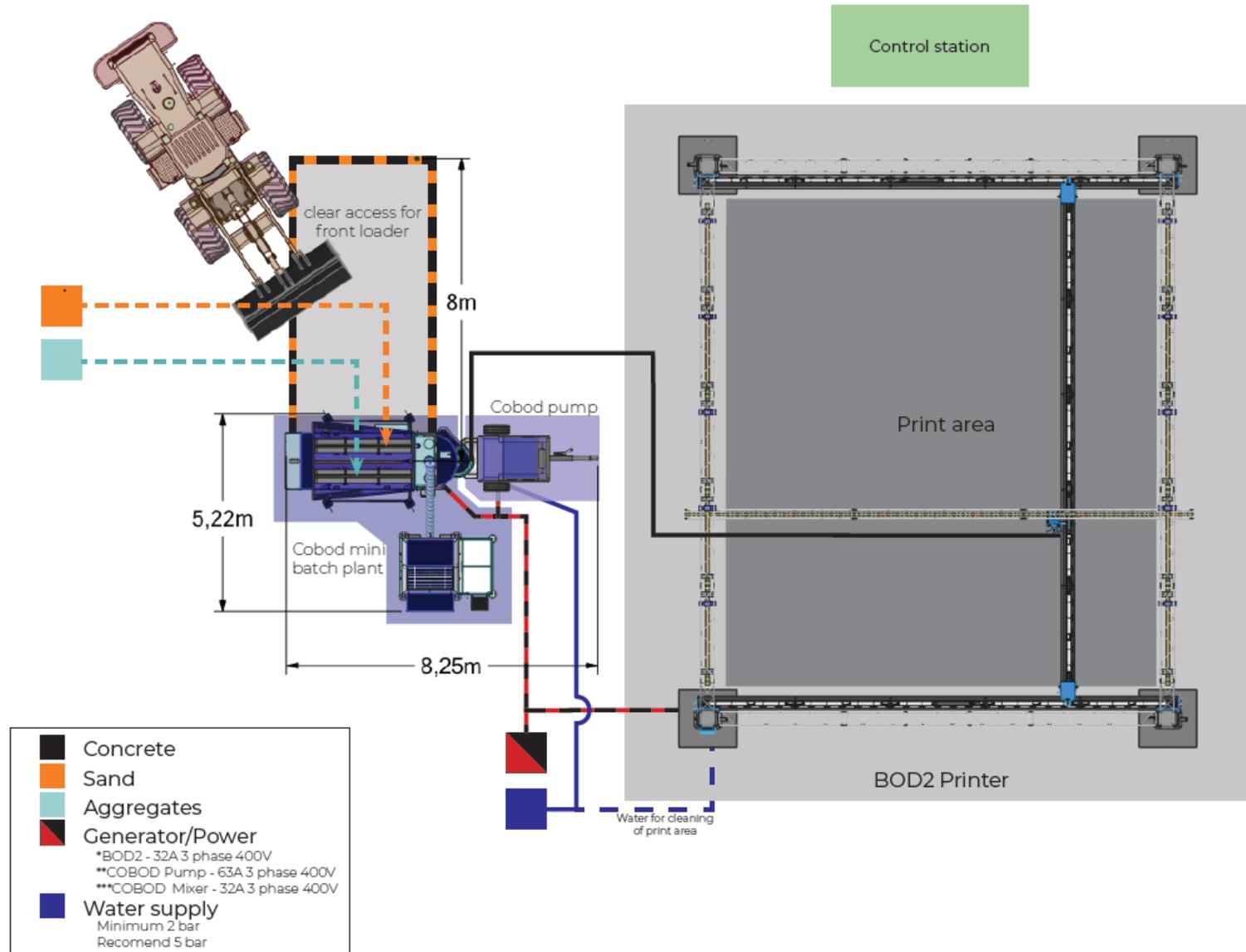
- Secondary operation of printer
- Assist on start-up and cleaning
- Assist on installation
- Assist on cleaning and maintenance



# SITE PREPARATIONS

## SITE LAYOUT

- ▶ Safety zoning on site:
  - Avoid personnel operating in a driving zone
  - Avoid cables laying in zones with traffic
  - Ensure enough space for operators to have a good view of the site
- ▶ If there is an existing foundation placed, it is important to ensure that the print area covers the entire foundation
  - COBOD recommends that only the bottom slab is poured before the printer is installed with a good amount of tolerance (+200mm). The top foundation is then printed as formworks which will ensure a precise fit once the printer is installed.
- ▶ Important to ensure enough space around the cement and aggregate silos for a front loader to refill.
- ▶ Consider storage for raw materials
- ▶ Ensure correct utilities on site
  - Water: 2 bar minimum, 5 bar recommended
  - Power:
    - 380-480V @50-60Hz
    - 32A pre-fuse
    - 300mA RCCB
- ▶ Ensure soil is well compacted
  - Minimum 250 kN/m<sup>2</sup> required (5.3 Pound/sq. ft.)





# KPI'S FOR SHIPPING AND INSTALLATION

## INVENTORY MGMT

Ensuring that all parts arrive on site in time. Keeping accurate shipping lists and verifying shipments before shipping

Measurement:  
% of parts arriving on site in time

**GOOD: 100%**

**POOR: 95-98%**

**UNACCEPTABLE:  
< 95%**

## POSITIONING

Correct positioning of the 3D printer on site in relation to surveyor. Better positioning will give more room for the operator. Critically important if the full printing area will be utilized.

Measurement:  
Deviation from optimal placement in mm

**GOOD: 0-30mm**

**POOR: 30-50mm**

**UNACCEPTABLE:  
> 50mm**

## ALIGNMENT

Alignment of the Z axes during installation and Z+Y carriages after installation. Crucial to machine performance. Poor alignment can result in poor print quality and damage to the equipment

Measurements:  
Deviation in mm  
Deviation in deg

**GOOD:  
< 5mm  
< 0.1 deg**

**POOR:  
5-10mm  
0.1-0.5 deg**

**UNACCEPTABLE:  
> 10mm  
> 0.5 deg**

## PERFORMANCE

Ensuring that the printer is properly stable, can smoothly run at its intended speed and all safety functions engage properly.

Measurement:  
Site Acceptance Test

BOD2 System Verification					
Omron Version:		Device	IP/Name	User	Pass
Configuration:		IPC			
Duet version:		Router			
Location:		Duet			
Responsible engineer:		Cam1			
		Cam2			
		WiFi			
Overview & Sequence					
#	Phase	Description			
0.	Overview and Prerequisites	Overview of the processes involved for full system check as well as validation machine parts and elements, prior to the system verification processes			
1.	Installation Verification	Printer Full assembly and setup following guidelines for correct distances and alignment verifications: Zg to Zc, Z perpendicularity Y-X-Y height alignment using Multiline laser X-Y perpendicularity verification			

# PRINTER INSTALLATION

## INSTALLATION PROCEDURE

### Pre installation

- ▶ Ensure shipment is correct:
  - Check parts received with shipping list.
  - Check for damaged parts in shipment.
  - Take the opportunity to familiarize yourself with the names of the components.
- ▶ Ensure site has sufficiently stable soil:
  - 250 kN /m2 is required.
- ▶ Ensure space for installation:
  - Refer to printer installation size in size sheet.
- ▶ Ensure utilities are in place:
  - Refer to “power and water requirements” sheet.

### Printer installation

- ▶ Install printer concrete feet:
  - Ensure positioning is within specifications
- ▶ Install Z columns
  - Ensure alignment is within specifications
- ▶ Install Y axes
  - Ensure alignment is within specifications
- ▶ Install X axis
  - Ensure alignment is within specifications
  - Lock Axis in place with end-plates
- ▶ Install E-chains and cables
  - Ensure correct fit and tightness
- ▶ Connect power
- ▶ (Optional) Place industrial plastic tarp on top of printing area if you are performing test prints.
- ▶ Perform Y and Z carriage alignment
- ▶ Perform master homing
- ▶ Install print head

### Site acceptance test

- ▶ Safety checks
  - Check all Estops
  - Check print head safety switches
- ▶ Performance test
  - Check movement directions on all axes
  - Check movement on full axes
  - Check material hopper sensor functionality and setting
  - Check pump signal
- ▶ Test cameras
  - Ensure connection to cameras

# ▶ PRINTER SIZE AND MEASUREMENTS

- ▶ Accessible in COBOD Library
- ▶ Used to calculate all necessary measurements when installing the printer
- ▶ Used to get key measurements for the design phase
- ▶ Based on printer version

**Calculator for positioning of a BOD2 3D printer**  
for V240 or newer

Numbers for calculations					
Adjustable cells:					
Number of X-modules	Number of Y-modules	Number of Z-modules	Number of Z-legs	Height of concrete base [mm]	Hose management
3	3	3	4	0	No

Length of a module in mm	2525,84
Distance between center of Z-truss and first X-truss	992,21
Distance between surface of Z-carriage and first X-truss	389,1665
Distance between surface of Z-carriage and printnozzel	618,

618,

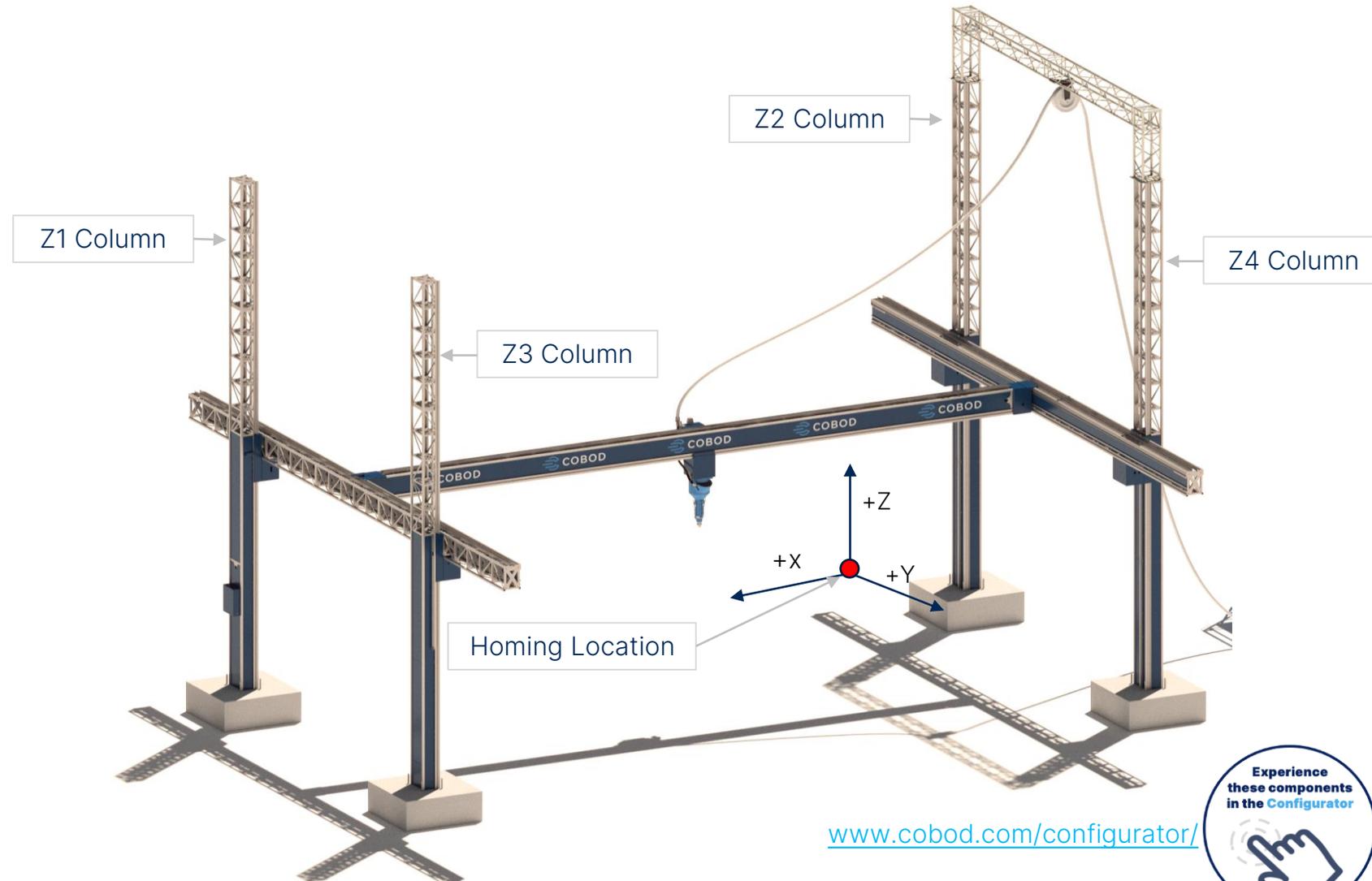
Y  
X

Legend:  
■ = Z leg  
■ = Z carriage

# Z'S AND COORDINATE SYSTEM

## BOD 2

- ▶ Z axes installation begins with the installation of the Z1 concrete base.
- ▶ Consider printer arrangement when designing project in CAD/Slicer.
- ▶ Installation Sequence:
  1. Z1 is placed first
  2. Z2 is placed across from Z1
  3. Z3 is placed next to Z1
  4. Z4 is placed across from Z3
  5. After this the pattern is repeated based on your configuration. (see to the right)
- ▶ It is important to note that the origin for our machines is placed at the Z2 column (at master homing location)
  - +Y is to the right of Z1, -Y is to the left of Z1
  - +X is TOWARD Z1, -X is away from Z1
  - +Z is up, -Z is down



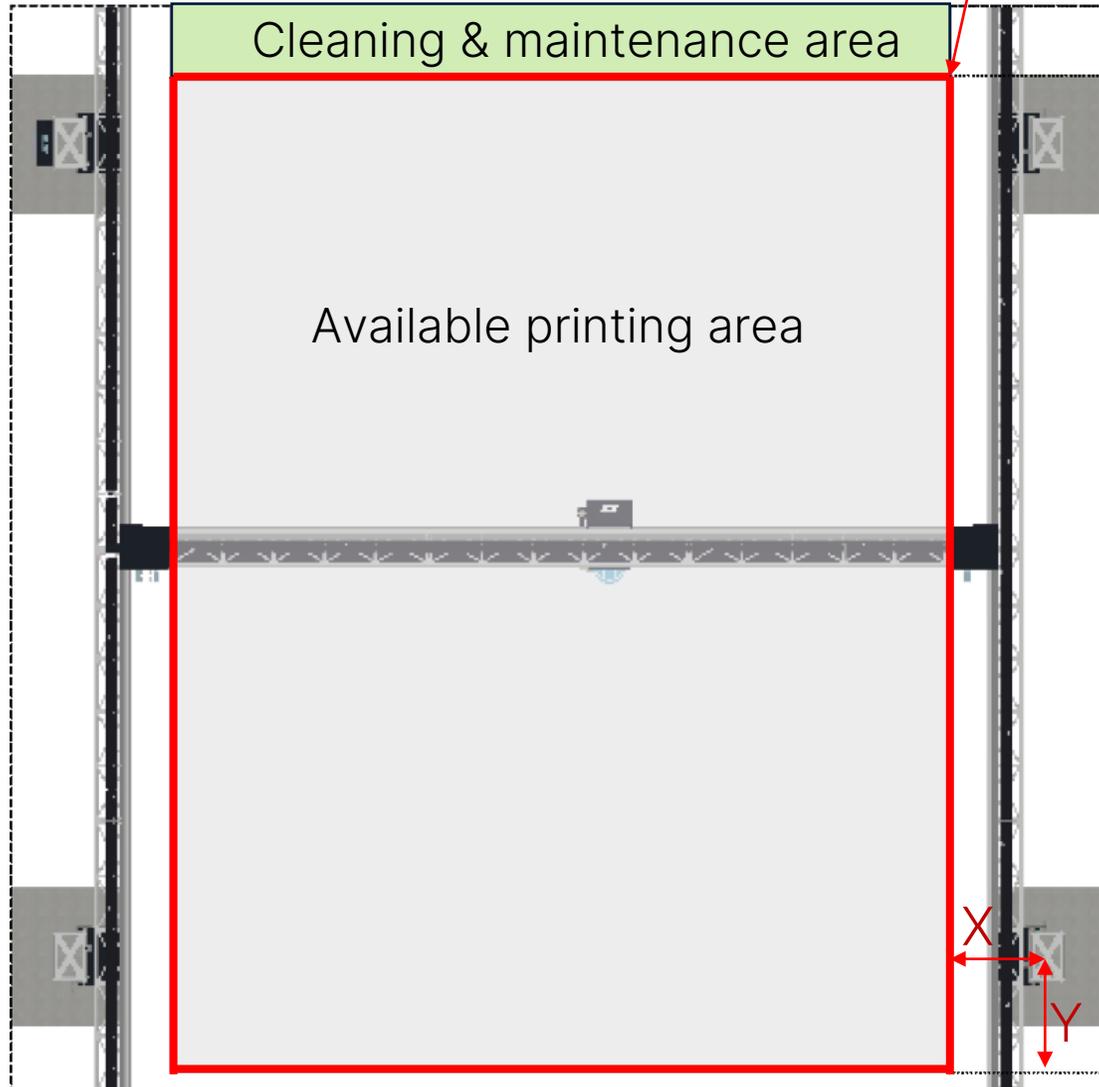
[www.cobod.com/configurator/](http://www.cobod.com/configurator/)

Experience  
these components  
in the Configurator



# PRINTER POSITIONING

## CONCRETE FEET POSITIONING



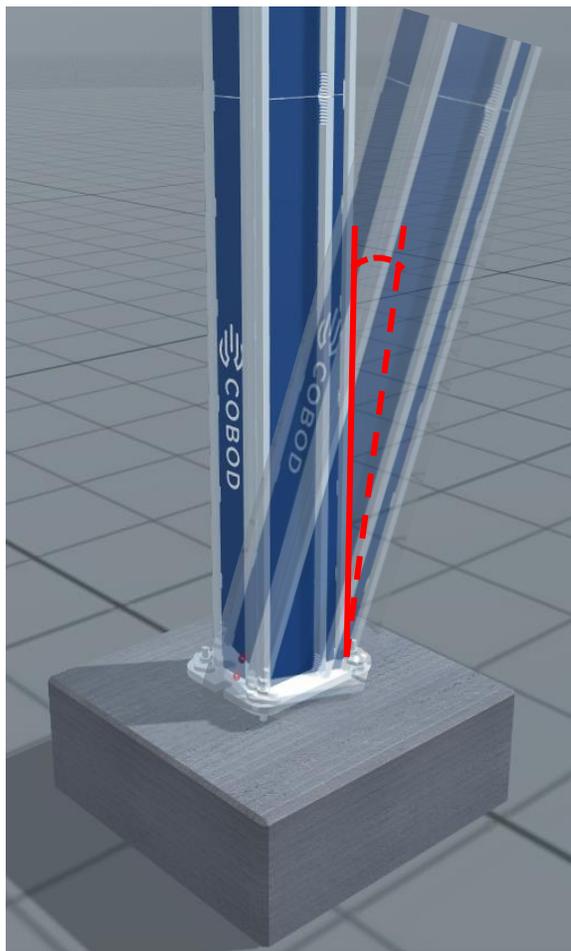
50mm Edge clearance tolerance

- ▶ The position tolerance for placing the concrete feet in relation to the intended print area is +/- 25mm in both X and Y direction
- ▶ Note that COBOD recommends a minimum clearance of 200mm total in both X and Y when designing a building to fit inside the printer area.
- ▶ Measure from the center of the column to the starting point of the house.
- ▶ X distance to closest nozzle position: XXX
- ▶ Y distance to closest nozzle position: XXX

# PRINTER POSITIONING

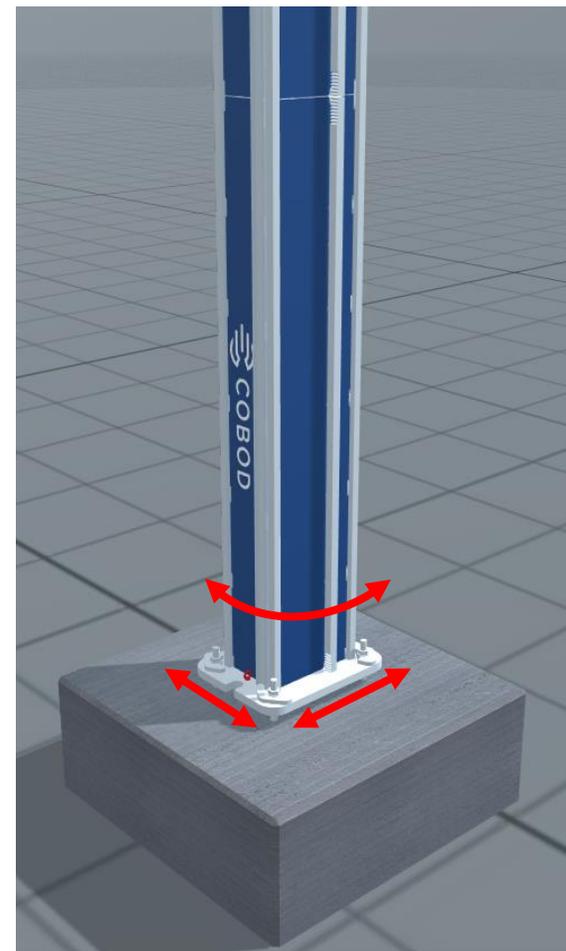
## Z COLUMN POSITIONING AND LEVELLING

### Levelling



- ▶ Always perform levelling before positioning.
- ▶ After positioning, verify level again
- ▶ Level is measured using a spirit level and must be within 0.1 deg of vertical measured on both sides
- ▶ Nuts on mount bolts are adjusted to adjust level

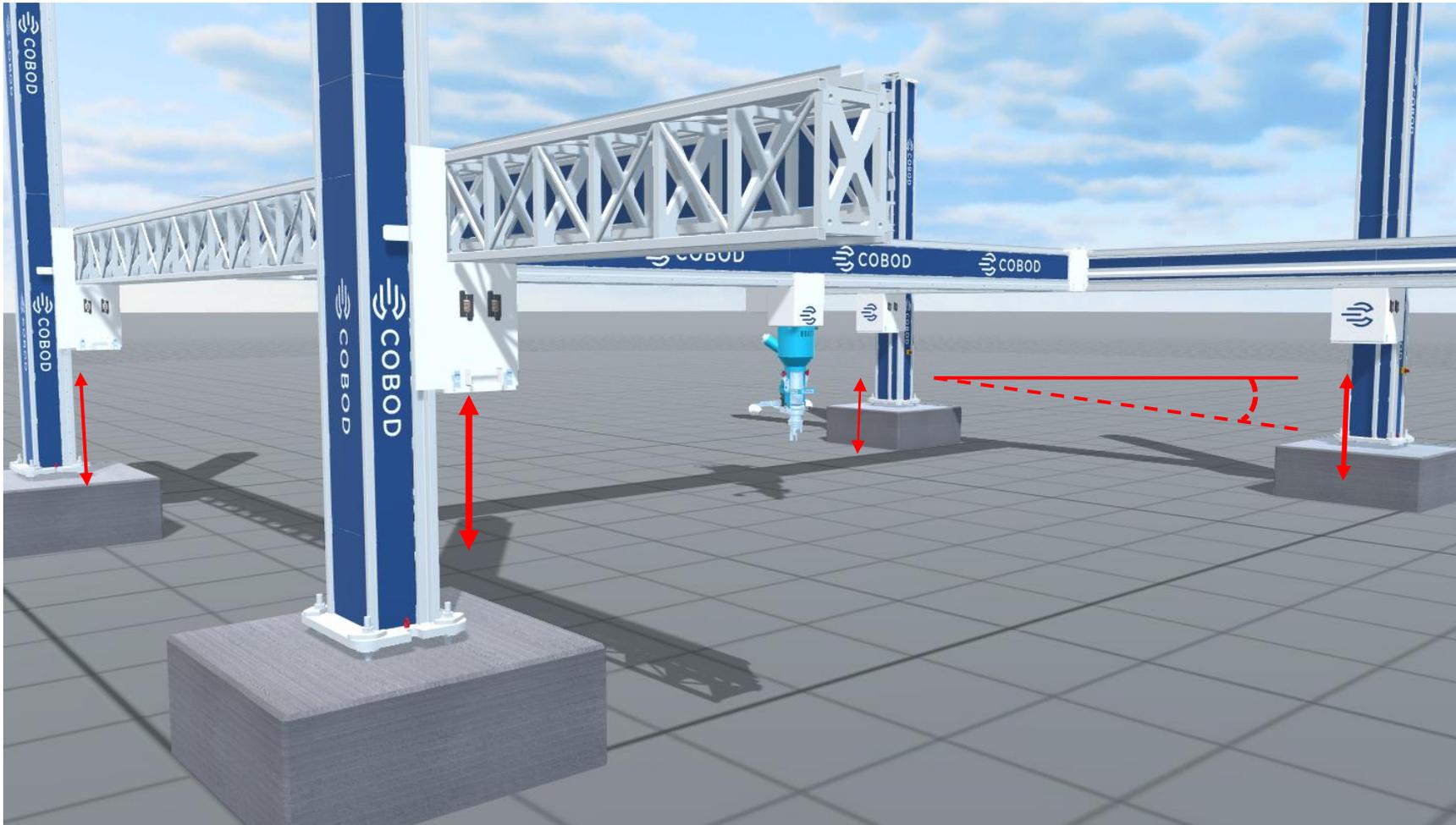
### Positioning



- ▶ Positioning is always done after levelling
- ▶ After positioning, verify level again
- ▶ Positioning for the first Z column (Z1) is measured in relation to the desired placement of the building
- ▶ Position of the remaining 3 Z columns are measured in relation to Z1
- ▶ Measurements are made using a laser measurement device
- ▶ Distances between columns are found in the calculation sheet in COBOD library
- ▶ Tolerances in X direction: +5mm (distance cannot be smaller than the indicated)
- ▶ Tolerances in the Y direction is +-5mm
- ▶ Rotation must be within 0.5 deg

# PRINTER ALIGNMENT

## Z CARRIAGE ALIGNMENT



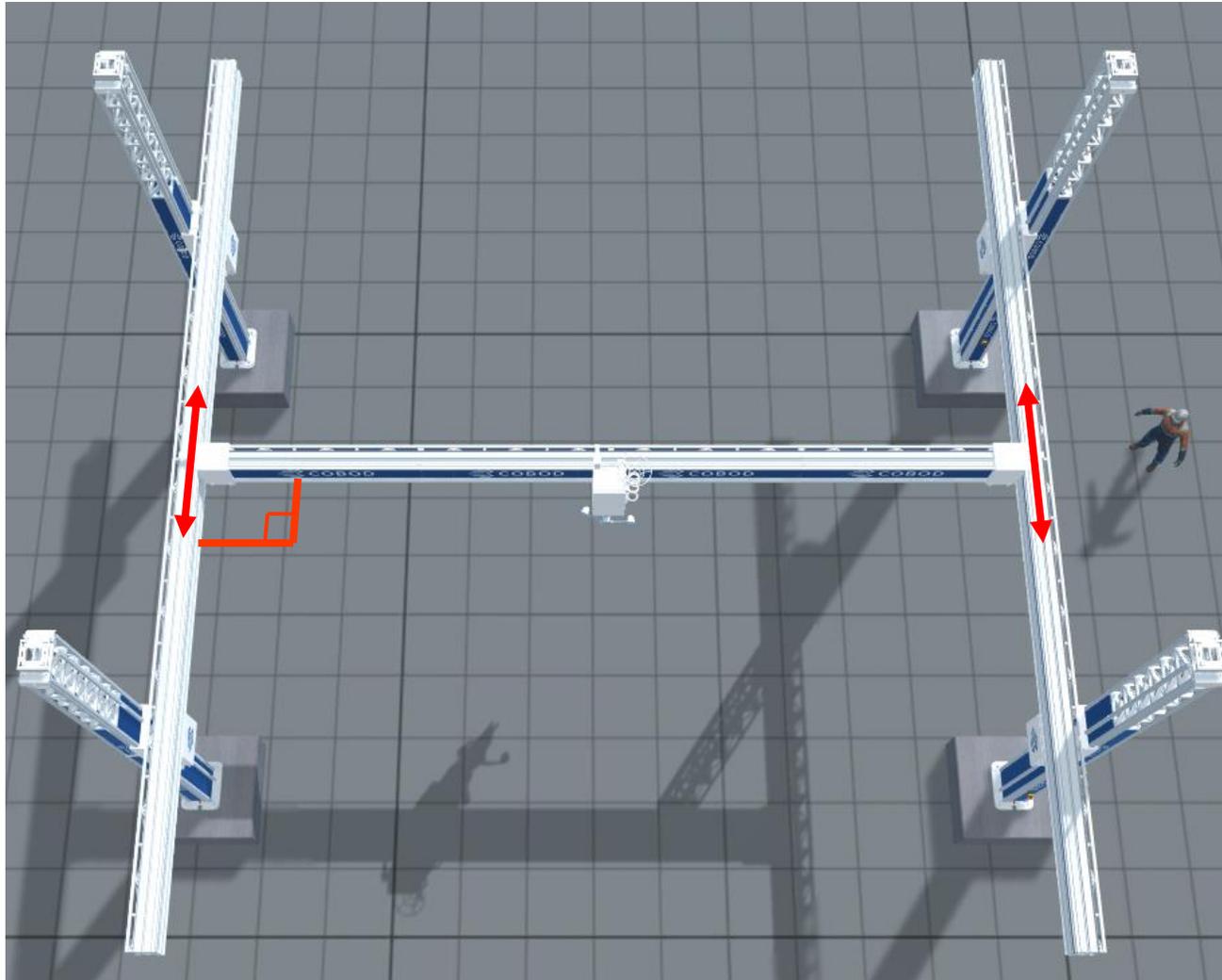
- ▶ Alignment Tools:
  - Z remote control
  - Spirit level
- ▶ Y beam is placed on top of Z1 column
- ▶ Starting at Z1, all Z carriages are aligned using a spirit level
- ▶ Alignment tolerance is +/- 0.1 deg to horizontal
- ▶ Spirit level is placed inside the rails to ensure best measurement
- ▶ Check both sides of the beam and the middle
- ▶ Must be reset after power off or E-stop

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# **PRINTER ALIGNMENT**

## Y CARRIAGE ALIGNMENT



- ▶ Y carriages are aligned to ensure perpendicularity of the X axis and Y axes
- ▶ Tools used:
  - Angular laser
  - SoftNA
- ▶ Tolerance is +/- 0.1 deg
- ▶ Must be reset after power off or E-stop

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# PERFORMANCE

## SITE ACCEPTANCE TEST

A Factory Acceptance Test (FAT) is performed at COBOD’s production during production and commissioning of each machine.

A Site Acceptance Test (SAT) is performed first time the printer is installed by COBOD’s installation and training team.

It is recommended, that the SAT is performed by the printer operator after each new installation to ensure the equipment it in overall good shape and avoid downtime during a project. COBOD provides the template for the SAT for the operator

### BOD2 System Verification

Omron Version:	
Configuration:	
Duet version:	
Location:	
Responsible engineer:	

Device	IP/Name	User	Password
IPC			
Router			
Duet			
Cam1			
Cam2			
WiFi			

#### Overview & Sequence

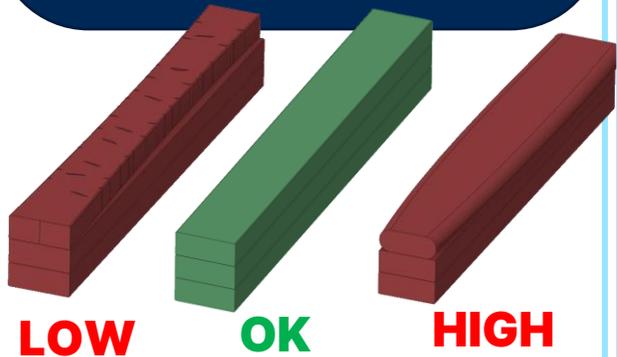
#	Phase	Description
0.	<b>Overview and Prerequisites</b>	Overview of the processes involved for full system check as well as validation of machine parts and elements, prior to the system verification processes
1.	<b>Installation Verification</b>	Printer Full assembly and setup following guidelines for correct distances and Z alignment verification: Zc to Zc, Z perpendicularity Y-X-Y height alignment using Multiline laser X-Y perpendicularity verification Static and Echain cable installation
2.	<b>Operational Verification</b>	Operational verification, performance verification, system verification
3.	<b>System Verification [SAT]</b>	SAT print using customer recipe, only customer recipe with D.fab solution *Minimum of 1h print *Centerlines containing challenging segments, i.e.: sharp corners along both X and Y *Minimum of 3 layers must be performed at 200+mm/s and carefully observed, highest speed possible for the printer and the site
4.	<b>Generate SAT Report</b>	*Note all relevant issues during Operational Verification, Performance Verification as well as SAT stages. *Reflect on aspects of the system and elements to be either corrected or adjusted prior shipment as well as during on site installation [SAT]

# KPI'S FOR PRINTER OPERATIONS

## LAYER QUALITY

Visually inspecting layer quality over the duration of the print. Adjust printer speed and extrusion speed to optimize quality.

Measurement:  
Visual inspection



## PRODUCTIVITY

Optimal build rate based on material, geometry and environment. Modified by adjusting speed and extrusion.

Measurement:  
Concrete output in m<sup>3</sup>/h

- **MAX: 3.6 m<sup>3</sup>/h**
- **DECENT: 1.5-3 m<sup>3</sup>/h**
- **LOW: 0-1.5 m<sup>3</sup>/h**

## EFFICIENCY

Ensuring a stable continuous process. Relation between projected time and actual printing time. Impacted by thorough maintenance, cleaning and quick resolution of errors

Measurement:  
Printing time to downtime ratio in %

- **MAX: 80-90%**
- **DECENT: 50-70 %**
- **LOW: 0-50 %**

## REPEATABILITY

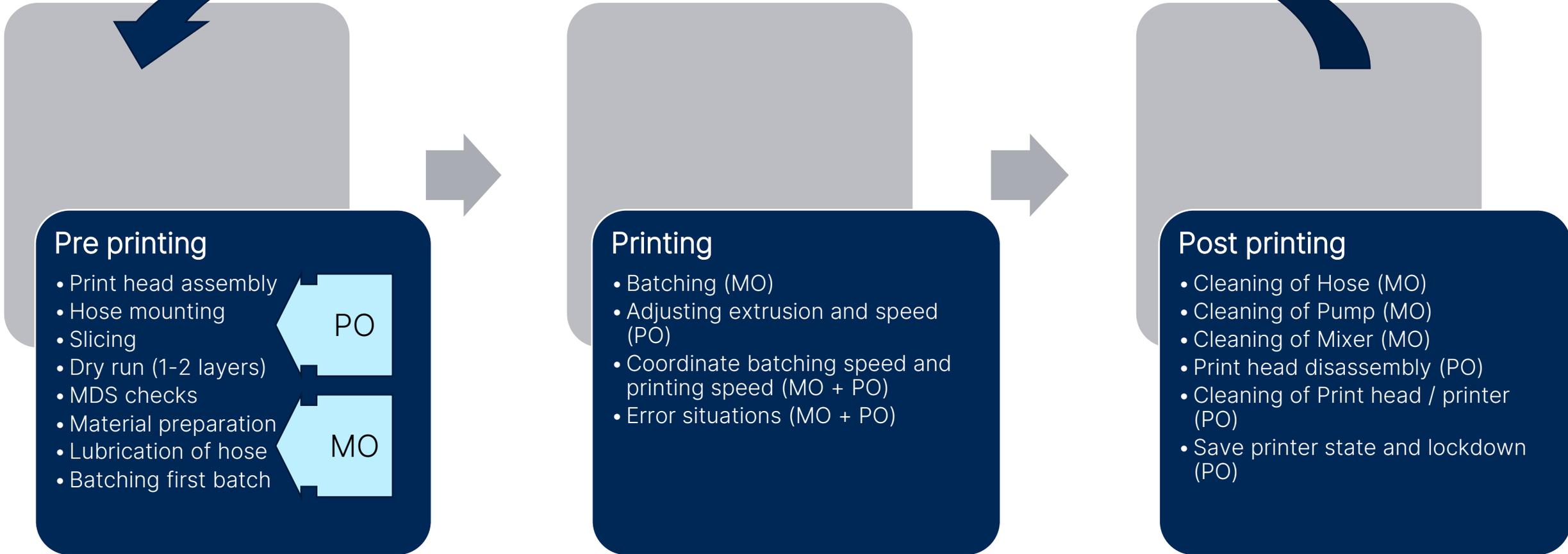
Print with repeatable tolerance and surface quality. Impacted by calibration of printer and thorough planning of printing activities as well as layer quality

Measurement:  
Layer-to-layer offset in mm

- **BEST: 0-2mm**
- **DECENT: 2-5 mm**
- **LOW: above 5mm**

# PRINTING PROCESS OVERVIEW

## PRINTING PROCESS



# MOST COMMON ERRORS

## 1. U axis (nozzle rotation) loose positioning

- Usually caused by either a failure to follow procedure when zeroing U axis or by not tightening the U axis
- Can be caused by concrete that is not cleaned properly after printing operations.
- X / Y alignment fails
- Usually caused by print head mount not perfectly similar to the day before.
- Solved by following a quick “realignment” guide.

## 2. Extruder clogs

- Usually caused by either a too high dosage of stiffener or after a break in extrusion.
- Can be caused by a sub-optimal material design or a mismatch between nozzle size and aggregate size

## 3. Extruder runs out of material

- Pump cable is disconnected or damaged
- Material sensor is dirty

## 4. Connection lost to DUET interface

- Wifi connection is poor.
- Operations can be continued using the touch screen interface until connection is re-established

## 5. Estop is pressed

- Omron interface / softNA will indicate if an Estop is pressed

## 6. Print head collision

- Print head has collided with the foundation, wall or obstacle, with new update it will automatically retract.

## 7. Poor cleaning or maintenance

- Poor cleaning can result in a long range of issues.
- Most common are U axis or Extruder axis stalling or losing position

# **MAINTENANCE**

Corrective

Preventive

Predictive

## GLOSSARY

- Operators Remote – yellow remote with key, pump control, E-stop, and green activation button
- E-Chain – black modular chains that lay across the moving portions of the BOD to protect the wiring to each carriage
- E-Box – “Electronics” box, the main one being at the Z1 leg
- E-Stops – Emergency stops that immediately turn off the high power of the machine and stop it instantly in the case of an emergency or collision
- Carriage – the boxes at the beginning of the axes that contain the motors, drivers, and electronics that make motion possible(1 X, 2 Y’s, varying Z’s on configuration)
- AHMS – Advanced Hose Management System
- Allu trusses – 40x40cm aluminum trusses that make up the traditional HMS, they vary in length depending on configuration of the machine
- Soft NA – main interface of the machine that includes alignment, troubleshooting, machine settings, and basic setup.
- Z-Lift – upward motion of entire system via the Z-carriages
- Duet – secondary interface of the machine that includes print files, work coordinate systems, macros, and g-code commands/configuration files.
- M.O – Material Operator
- P.O – Print Operator
- MDS – Material Delivery System
- Clickers – Limit switches on the carriages that prevent the axes from running off their tracks, they are also used in the homing process to determine the maximum print area.

## REMOTE SUPPORT AND DEBUGGING

Implementing new technology such as a 3D printer into the construction site requires a lot from the user. In this regard, it is important to highlight, that COBOD strives to provide world class training for the operators before and after a printer is on site.



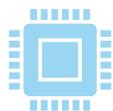
However, experience shows, that we still face new challenges when entering new areas. We are focused on getting your team up to the required level as fast as possible, but you should not expect to be masters on your first project. A lot of learnings must be acquired through experience and repetition, for this, we recommend you take the time to review all material.



COBOD strives to be available to help and support you, not only during the training period, but also especially in the first time after you start your projects. At all times, if you experience issues or have general technical questions, reach out to [techsupport@cobod.com](mailto:techsupport@cobod.com).



A hotline service has been established as well. It is only available currently during Danish work hours, but we aim to have our hotline open for US working hours by end of summer. Please submit a ticket before calling



To ease the task of remote support you must acquire an LTE sim card with a data plan and insert it into the LTE router in the main ebox. This way, our tech support can access and support you remotely to reduce overall downtime

# **CERTIFICATION TEST**

## TEST CRITERIA

- ▶ Link:  
<https://www.flexiquiz.com/SC/N/8ca31c72-61ee-4583-b019-7850e5d49788>
- ▶ Time limit: 15 minute.
- ▶ Dynamic: All documents can be used as help.
- ▶ Approval: At least an 70% score to pass.
- ▶ Sequenced: Need to pass Level 1 test before proceeding to site training (Level 2).

**Thank you  
for your attention**

