

STANDARD OPERATIONAL PROCEDURE (SOP)

BOD3

3D CONSTRUCTION PRINTER



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DOCUMENT VERSION

LATEST REVISION

1.2 – May 2024

DOCUMENT VERSION

BOD3-SOP-V1

Please note that the latest official versions of the SOP are available on our COBOD Connect platform.

DOCUMENT VALID FOR THE FOLLOWING VERSION OF THE PRODUCT

Item	Model	Version Control	AHMS	PLC (SoftNa)	Duet	Rewind
Version	BOD3	V009Production	DN75mm	2022R1	3.4.0	0.5.0

DESCRIPTION OF CHANGES

#	Change/Edit
1	
2	
3	
4	
5	

PUBLISHER

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LANGUAGE

 English (US)

WARNING

 Please read all instructions thoroughly before operating the equipment.

1. GENERAL INFORMATION

1.1 SCOPE

The BOD3 Standard Operational Procedure (SOP) comprehensively outlines the standard procedures for installing and operating the BOD3 3D Construction Printer. This equipment is specifically engineered for 3D printing structures using a continuous linear printing technique. Its track system enables seamless horizontal movement along the Y-axis, making it perfectly suited for mass production printing projects such as attached, semi-detached, and standalone housing projects.

The document does not cover:

- Design, modelling, or slicing – Please refer to the *3D Modeling and Slicing SOP*.
- Material Specifications – Please refer to *D.fab SOP*.
- Material Delivery Systems – Please refer to both the *COBOD Batch Plant SOP* and the *COBOD Pump SOP*.
- Waste treatment protocols – Please refer to your local code for guidelines.
- Additional construction equipment, third party accessories, and/or general site safety – Please refer to the manufacturer's instructions and/or local code.
- Please see the *Related Documents* section of this document for more information to support the application of the BOD3 3D Construction Printer.

1.2 APPLICABILITY

The BOD3 Standard Operational Procedure serves as the primary field reference for BOD3 certified operators in the following scenarios:

- L2 Training (on-site)
- Packing and unpacking for shipping
- Installation and disassembly
- Operational procedure
- Cleaning
- General maintenance
- Troubleshooting

All site personnel must familiarize themselves with the Environmental Health and Safety (EHS) section of this document, as well as any other applicable local regulations.

1.3 DEFINITIONS

3D construction printing uses both general and industry-specific terminology. This document also includes terms unique to this printer model, listed below. For a detailed explanation of the various machine components, please refer to the System Overview section.

Terminology	Definition
3DCP	3D Construction Printing (sometimes referred as 3D Concrete Printing).
3D Model	Digital representation of a structure, used as basis for any 3D printed building.
AHMS	Advanced Hose Management System: A series of DN75 pipes and Ø75mm hoses and various metal parts that fasten to the printer acting as a conduit for material.
BOD3	3D Construction Printer made by COBOD.
Crossbeams	Squared metallic profiles that connect Y modules with scaffolding feet.
C-Chain	Plastic host for concrete hoses.
Dyneema ropes	Tensioning ropes that secure the Z-connection system.
Duet	Operator's Web interface to the BOD3. Controlling the printer during Printing Operations.
DS	Dosing System.
Drag chain	Plastic chain used to house concrete hoses for the advanced hose management system.
Driving plates/crane pads	Plastic sheets/blocks on the ground, onto which the scaffolding feet sit. distributes the load of the printer on the ground.
GC	General Contractor.
Guide tray	Stainless steel parts that control the linear movement of e-chains and AHMS drag chains along the X and Y axes. connect to X axis AHMS hooks and Y1 crossbeams.
Homing	Slowly moving the printer to its machine origin for X automatically.
HMI(Soft-NA)	Human Machine Interface (software interface).
IPC	Industrial Personal Computer (hardware interface).
KPI	Key Performance Indicators.
L1	Level 1: Online introduction training.
L2	Level 2: On-site introduction training.
Mastering	Setting each individual axis to zero.
MO	Materials Operator.
MOA	Materials Operator Assistant.
MDS	Material Delivery Systems.

PO	Printer Operator.
PLC	Programmable Logic Controller.
POA	Printer Operator Assistant.
PM	Project Manager.
PH	Printhead.
Slicer COBOD Slice	A type of software, developed to translate the information from a 3D model into machine code that can be read by a BOD3.
Scaffolding feet	Physical point of contact between Y-trusses and the supporting surface.
SAT	Site Acceptance Test.
SM	Site Manager.
Truss wheel jack	Wheel assemblies that fasten to Y1 and Y2 crossbeams during printer installation, allowing for easy positioning and alignment of Y trusses. Adjustable in Z direction.
WCS	Work Coordinate System.
X / Y / Z / E / U	Movement direction within the X, Y, and Z cartesian coordinate system. E and U refer to rotational movement.
Module(s)	X, Y and Z units that together inform a machine configuration.
Truss	A series of X, Y or Z modules together creating a physical element to install. Eg. "That Y1 truss has five modules".
X axis rollers	Load bearing support for the upper/gliding section of AHMS C-chain on the X-axis.
Y axis rollers	Allows for upper/gliding section of AHMS C-chain to move over a certain point along the Y-axis, replacing guide tray.
ZCS	Z-connection system, T-bracket in the X direction made from alu trusses fastened together.

1.4 ROLES & RESPONSIBILITIES

The installation, operation, and maintenance of the 3D printer are the responsibilities of a certified operator, who must have successfully completed Level 1 (online) and Level 2 (on-site) of COBOD's training programs, or an equivalent program offered by one of its certified affiliates.

The responsibilities of a certified operator are:

- Printer installation
- Printer operation
- Verification of CAD models
- Preparation of 3D printable files (slicing)
- Printer cleaning
- Printer maintenance

A typical site crew includes a Project Manager or Site Manager (PM/SM), a Printer Operator (PO) and their assistant (POA), a Materials Operator (MO), and their assistant (MOA). Assistants serve as holiday backups and/or as part of rotating crews for 24-hour operations.

Project Manager/Site Manager		• Project planning, scheduling, and logistics • Coordinate with external suppliers • Coordinate with general contractors • Day-to-day site management	
PO	• Printer installation • Printer operations • Verification of CAD models • Preparation of 3D printable files (slicing) • Printer cleaning • Printer maintenance • Printer shipment	MO	• MDS (Material Delivery System) installation • MDS operations • Quality assurance of materials • MDS cleaning • MDS maintenance • Batching of concrete • MDS shipment
POA	• Secondary operation of printer • Assist with printer installation • Assist on start-up and shut-down procedures • Assist on cleaning and maintenance	MOA	• Secondary operation of MDS • Assist on MDS installation • Refill cement and aggregate silos • Assist on cleaning and maintenance

Furthermore, as with most construction sites, having a safety coordinator, certified telehandler operator, and surveyor will add significant value throughout the project. Alternatively, certifying the personnel mentioned above in these disciplines can ensure maximum efficiency.

1.5 TOOLS

When setting up and operating the BOD3 3D printer, it is crucial to have the right tools. COBOD provides ready-to-use tool kits containing all necessary items for on-site use. The most important tool kits include:

- BOD3 Setup and Maintenance Kit
- BOD3 Printing operations Kit
- BOD3 Spare parts Kit
- Materials kit

If you choose to source the tools locally, you can use the tool kit overview as a checklist, which is available on COBOD Connect (www.connect.cobod.com).

In addition to the physical toolkits, a Windows-based tablet is required to operate the printer wirelessly. The technical specifications for this tablet will be provided during the L1 training.

Physical tools	INSTALLATION	OPERATION	MAINTENANCE
BOD3 Setup and Maintenance Kit (COBOD can supply)	X	X	X
BOD3 Printing operations Kit (COBOD can supply)		X	X
BOD3 Spare parts Kit (COBOD can supply)			X
Materials Kit (COBOD can provide references)		X	
Equipment			
Crane – requirements:	X		
- Lifting capacity of 4 tons in 5 meters - Lifting capacity of 2 tons in 14 meters			
- Boom loader/telehandler – requirements: - Lifting capacity of 2 tons in 5 meters - Including shovel + extended forks		X	
Digital tools			
Windows-based tablet	X	X	X
COBOD Slice Software		X	

1.6 ENVIRONMENTAL HEALTH AND SAFETY (EHS)

EHS (Environmental Health and Safety) is the backbone of operational efficiency when correctly implemented, aiming to protect people, assets, and the environment during projects involving the BOD3 3D printer. It is the responsibility of the general contractor or project management team and must comply with all applicable local and federal regulations throughout each stage of the construction process. Failure to comply could result in accidents, negative media exposure, and delays in technology adoption. The primary goal of EHS is to protect workers from job-related injuries and illnesses by identifying and mitigating physical, chemical, and biological hazards in the workplace. This includes continuous updates to training and communication to maintain a safe and healthy work environment. Furthermore, by reducing labor, 3D printing could contribute to a safer working environment. However, the few workers on-site must adhere to a structured risk assessment and operational EHS program.

Before operating any heavy-duty equipment, including a 3D construction printer, it is recommended that employees undergo some basic construction training courses. These can include:

- Fall Protection
- Electrocution
- Struck-By
- Caught-In/Between Hazards
- Health Hazards
- Material Handling
- Tools - Hand and Power
- Managing Safety and Health
- Stairways and Ladders
- Fire Protection and Prevention

- Scaffolds
- Cranes
- Excavations
- Concrete and Masonry
- Personal Protective Equipment
- Confined Space Entry
- Signs, Signals and Barricades

We strongly advise customers, general contractors (GCs), and developers to assess the risks at their individual construction sites to ensure a safe workplace. It's crucial to provide proper training and certification for project overseers (POs) and maintenance overseers (MOs), aligning with local and federal guidelines for construction worker safety.

1.7 KEY PERFORMANCE INDICATORS (KPI)

Key Performance Indicators (KPIs) are vital metrics that track progress toward specific goals. They serve as focal points for both strategic and operational enhancements, offering an analytical foundation for decision-making while directing attention towards priority areas.

In the following section you will find KPI's for:

- Shipping
- Installation
- Printing operations

These considerations are particularly crucial when initiating a new printing project and/or relocating to a different site.

1.7.1 KPI'S FOR SHIPPING

Inventory Management: This involves ensuring timely arrival of all parts on-site, updating shipping lists, and verifying shipments before and after dispatch.

Equipment handling: Monitoring all loading and offloading operations is essential to prevent dents or damage to equipment during rigging. It's crucial to note that damage during rigging is the primary cause of harm to the printer.

TITLE	MEASUREMENT	ACCEPTABLE	DECENT	UNACCEPTABLE
Inventory management	Parts arriving on site in time (%)	100 %	95-98 %	< 95 %
Equipment handling	Damages when loading/offloading equipment (#)	0	1-2	3-5

1.7.2 KPI'S FOR INSTALLING

Positioning: Correctly positioning the 3D printer on-site relative to surveyor data is essential. Optimal positioning provides adequate space for the operator, which becomes especially critical when wanting to utilize the full printing area.

Alignment: Proper alignment of the Z-axes during installation, as well as the Z- and Y-carriages, is imperative for machine performance. Misalignment can lead to poor print quality and equipment damage.

Performance: It is essential to ensure that all quality checks are met after each installation by utilizing the Site Acceptance Test (SAT) document.

TITLE	MEASUREMENT	ACCEPTABLE	DECENT	UNACCEPTABLE
Positioning	Deviation from optimal placement in mm	0-30 mm	30-50 mm	> 50 mm
Alignment	1) Deviation in mm Y-Y distance 2) Perpendicularity between X and Y	1mm < 0.1 deg	1mm 0.1-0.5 deg	> 1mm > 0.5 deg
Performance	Site Acceptance Test	0 pending items	1-2 pending items	<2 items

1.7.3 KPI'S FOR PRINTING

Productivity per hour: Achieving the optimal build rate, considering factors such as 3DCP material, geometry, and environment. This can be adjusted by varying speed and extrusion.

Efficiency per Day: Maintaining a stable, continuous printing process by comparing projected time to actual printing time. Efficiency is enhanced through thorough maintenance, cleaning, and prompt error resolution.

Monthly Utilization: Tracking the number of printing days in a month to maximize equipment and personnel utilization. This enables faster return on investment (ROI) by scheduling consecutive projects throughout the year.

Layer Quality: Conducting visual inspections to ensure high-quality layers throughout the print. Adjusting printer and extrusion speeds optimizes layer quality. For material specific KPIs, refer to the D.fab SOP.

Repeatability: Printing with consistent tolerance and surface quality, measured in millimeters for accuracy. Calibration of the printer and meticulous planning of printing activities, along with attention to layer quality, affect repeatability.

TITLE	MEASUREMENT	GOOD	DECENT	UNACCEPTABLE
Productivity per hour	Concrete output in m ³ /h	>2.5 m ³ /h	1.5 - 2.5 m ³ /h	1.0 m ³ /h
Efficiency per day	Printing time to downtime ratio in %	80-90 %	50-70 %	0-50 %
Monthly use	Printing days per month	20 (excl. weekends)	12-15	>10
Layer quality	Visual inspection	Based on visual inspection		
Repeatability	Layer-to-layer offset (mm)	0-2 mm	2-5 mm	> 5 mm
Verticality	Degrees	90	89.99	>89.99

1.8 BOD3 TECHNICAL DATA SHEET

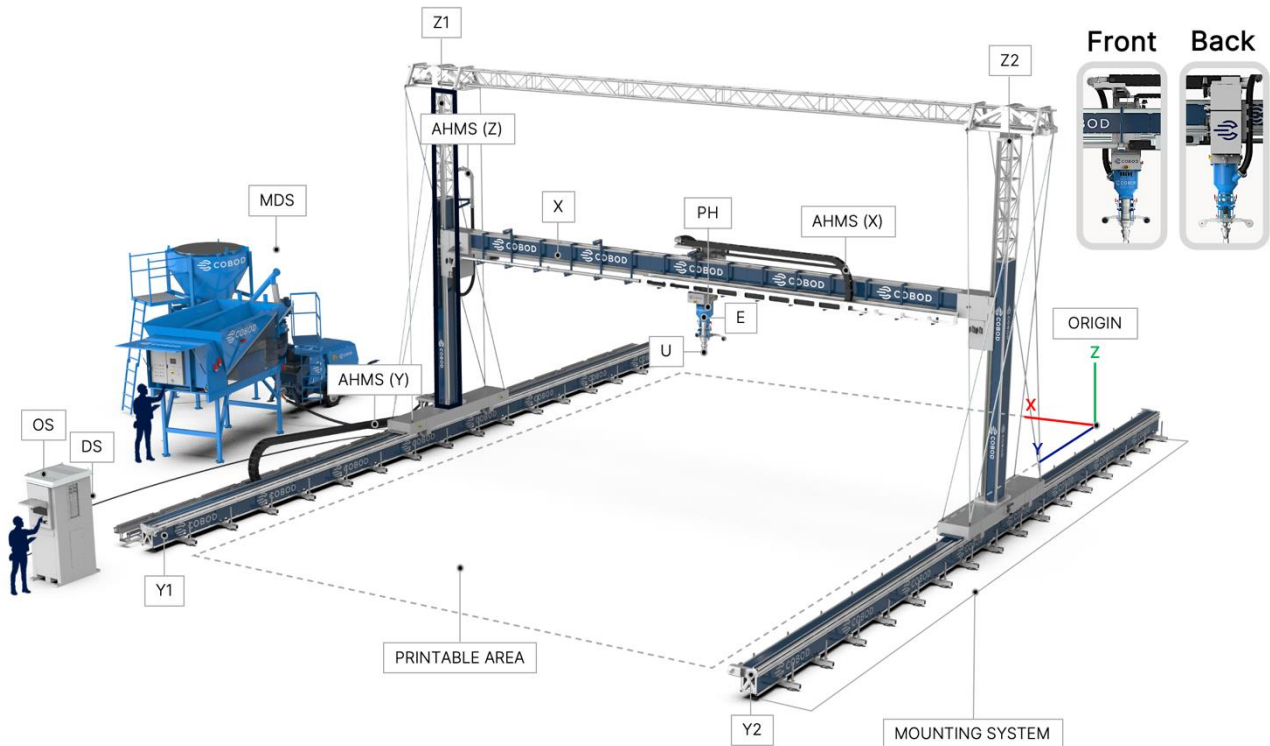
The BOD3 3D construction printer is a gantry-based printer designed for on-site construction. General technical information can be found below:

GENERAL INFORMATION				
Item	Description	Unit	Specification	
1.	Product	-	3D Construction Printer	
2.	Model	-	BOD3	
3.	Version control	-	V009 Production	
4.	Configuration min/max	X-Y-Z	Min 2X-3Y-2Z / Max 5X-12Y-4Z	
5.	Max width (X)	X modules	Min 2 modules / Max 5 modules	
6.	Max length (Y)	Y modules	Min 3 modules / Max 22 modules (+ unlimited when you move them)	
7.	Max height (Z)	Z modules	Min 2 modules / Max 3 modules	
8.	Layer height	mm	20-40 (COBOD standard steel nozzles)	
9.	Layer width	mm	50-80 (COBOD standard steel nozzles)	
10.	Weight (min/max)	Kg	Depends on configuration, please contact techsupport@cobod.com	
11.	Printable area (PA)	mm	Refer to <i>Measurements</i> chapter	
12.	Installation area (IA)	mm	Refer to <i>Measurements</i> chapter	
13.	Noise level	dB(A)	Max. 70	
ELECTRICAL SPECIFICATIONS				
14.	Current	A	EU value	US value
			32	30
15.	Voltage	V	400 (3 phases, + N + PE (WYE))	480 (3 phases, + N + PE (WYE))
16.	Frequency	Hz	50	60
17.	Motor movement system	-	Servo	
18.	General recommendations	-	Generator should have AVR (voltage regulator).	
PRINTING PRODUCTION				
19.	Machine operating temperature	°C	5-45	
20.	Optimal printing temperature (D.fab)	°C	10-35	
21.	Possible printing temperature (D.fab)	°C	5-45	
22.	Equipment manning	-	1 printer operator (PO) 1 printer operator assistant (POA) 1 material operator (MO) 1 material operator assistant (MOA)	
23.	Printer set up time with crane (experienced crew)	hr	Depends on configuration, please contact techsupport@cobod.com	

24.	Printer dismantling time with crane (experienced crew)	hr	Depends on configuration, please contact techsupport@cobod.com
25.	Average aggregate size	mm	8
26.	Max. aggregate size	mm	10
27.	Hose compatibility	mm	75
28.	Max. printing speed	mm/s	250
29.	Max. speed (Z-axis)	mm/s	50
30.	Average material flow	m3/hr	1.5-2.0
SAFETY FEATURES			
31.	Hopper grid protection	-	1
32.	Operational limit set-up mechanisms	-	Per axis
33.	Anti-whiplash hose point connectors	-	Per hose-to-hose connection
34.	Emergency stops (E-stops)	-	12 total
35.	Audio-visual	-	Signal lamp, single prolonged beep and error notification.
36.	Error notifications	-	On both interfaces
37.	Humidity indicators	-	Per carriage
38.	Shock absorbers	-	2 per Y-truss
39.	Inductive rail sensors	-	2 per Y-carriage
40.	Z-limit switch	-	1 per Z-column
41.	Bumpers	-	2 per Y-carriage
42.	Operational interface	-	COBOD Web Control Interface (Duet)
43.	Set up and calibration	-	SoftNA
44.	Supported browsers	-	Microsoft Edge, Chrome. Does not support Safari nor IOs systems.
45.	Connection	-	Wi-Fi or LAN
46.	Slicer	-	COBOD Slice (standard NIST g-code mostly compatible)
47.	Communication points	-	2 antennas, one in Operational Stand and another in the XUC carriage.
WARRANTY AND SERVICE			
48.	Factory warranty	-	14 months warranty from Ex Works delivery.
49.	Service packages	-	Bronze, silver, and gold

2. PRINTER SYSTEM OVERVIEW

2.1 PRINTER COMPONENTS



Definition

The BOD3 3D construction printer is a gantry-based 3D construction printer that is especially designed for on-site concrete printing of larger construction projects. The BOD3 operates through the Cartesian coordinate system, allowing the machine operator to move the printhead that extrudes the building material within the three-dimensional space. The printhead moves along the X-axis (width), the X-axis moves up and down the two Z-columns (height), and the whole X/Z-axes group moves along on the two Y-tracks (length). This gantry principle allows the printer to access any position within the printable area (PA), providing complete freedom of movement within the volume.

In addition to its primary functions, the BOD3 includes various additional subsystems that enhance its performance and versatility, ensuring optimal flexibility and precision in the printing process:

Main axes:

1. X-axis (X)
2. Y-axis, referred as two Y-tracks (Y1 and Y2)
3. Z-axis, referred as two Z-columns (Z1 and Z2)
4. E-axis (E)
5. U-axis (U)

Additional subsystems:

6. Material delivery system (MDS)
7. Advanced hose management system (AHMS)
8. Dosing system (DS)

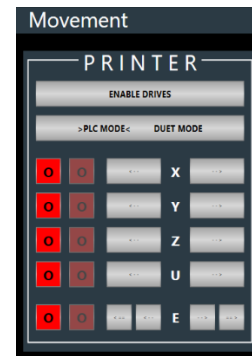
- The printer is controlled by a stand-alone cabinet called *Operational Stand* (OS) located near Y1 (highlighted above) but can also be operated remotely via tablet. This panel hosts a set of different functions that will be further described in the SOP.
- The printable area is the space where elements will be printed or “build” and is the only element that remains after the machine is removed.
- The logic of the placement for all additional subsystems is further described in the **Orienta-tion** section of this document. Water and power services are not displayed above.

Printer movement responds to the cartesian coordinate system for operations.

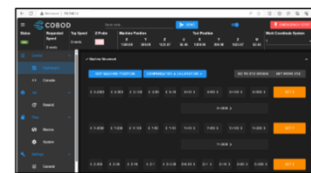
- Printer movement can be controlled from two different interfaces, from the Soft-Na (Operational Stand) in the tab *Movement* or Duet web interface (tablet/laptop). Both movement control interfaces can be seen to the right.
- +U movement turns clockwise while the +E movement turns counterclockwise.
- +X always moves towards Z1.

Location: Operational Stand

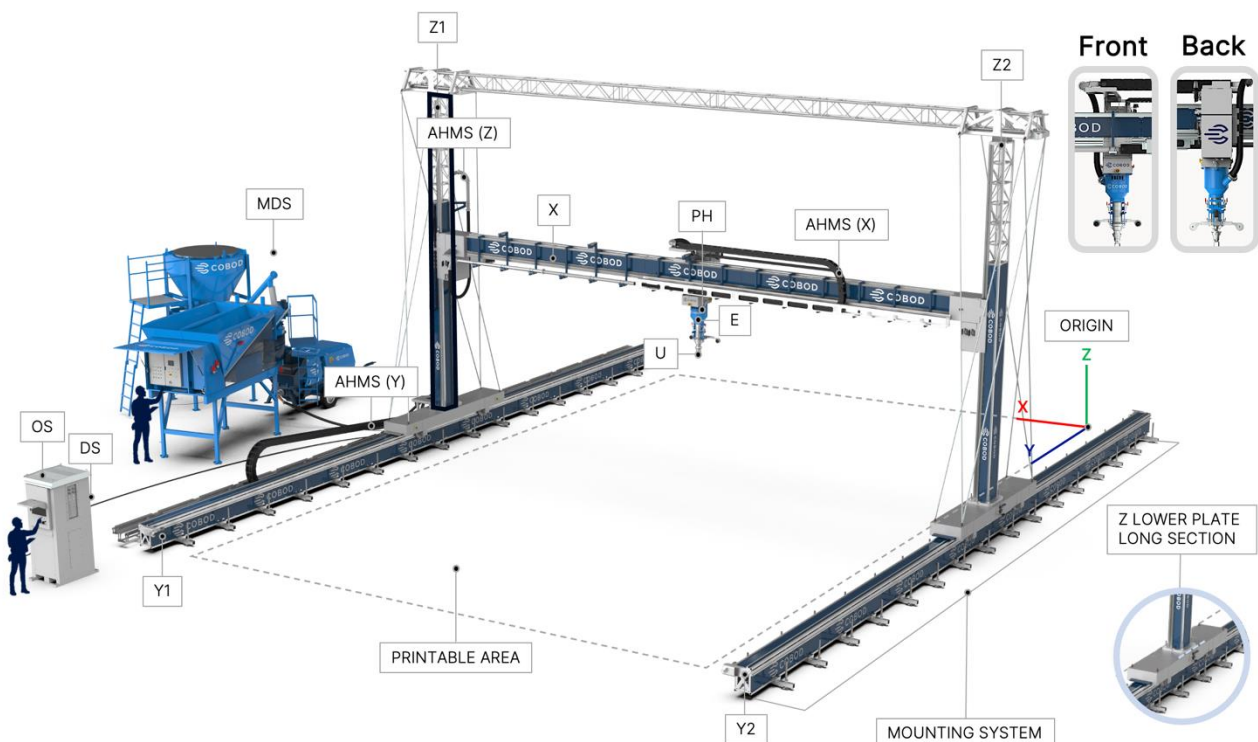
- E-chains and hoses also move following the printer's direction. Beware of hoses placed in the ground as well as any other cable.
- The origo, also known as origin, is always placed on the Y2, -Y corner on the "back" side of the printer.
- The printhead "front" is always placed on the +Y direction.
- The Y-AHMS loop turns towards Y1, +Y while the X-AHMS loop turns towards -X.



Duet Interface
Location: Tablet



2.3 PRINTER ORIENTATION



Definition

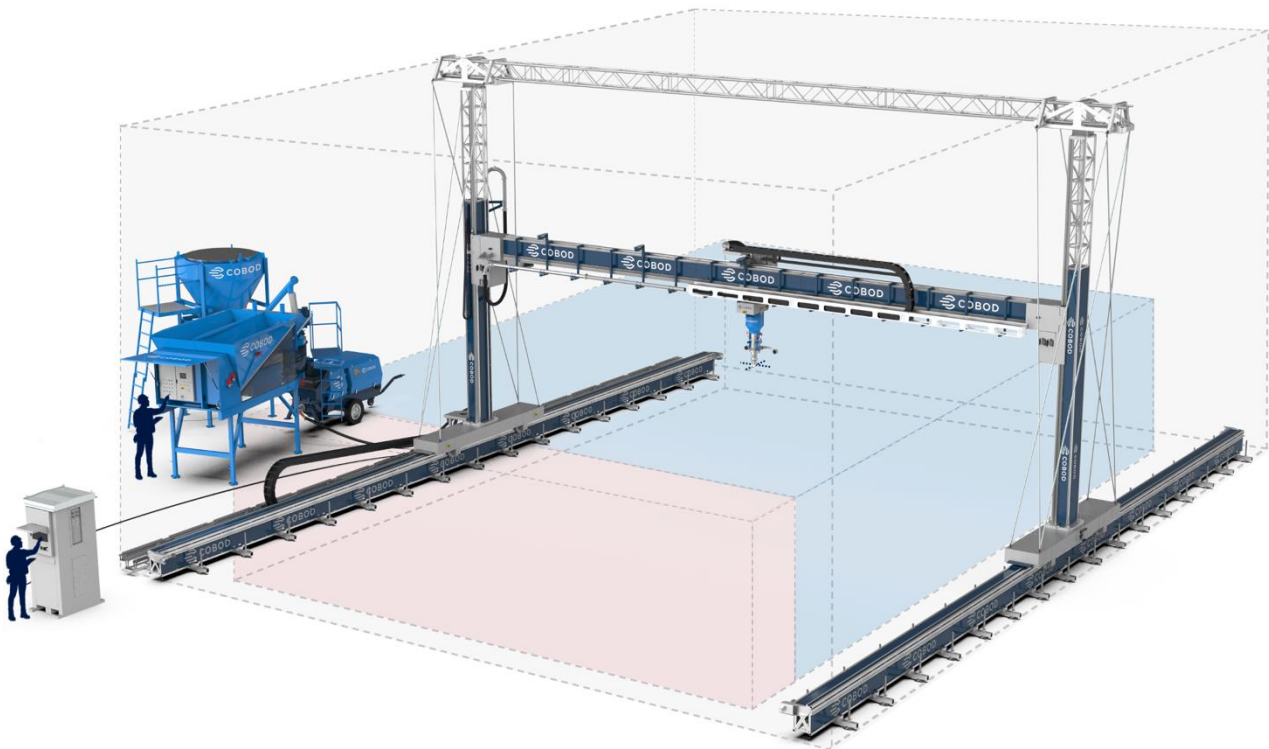
Orientation refers to the correct placement of external subsystems in proximity to the printer such as the AHMS, MDS and OS as well as their relationship with other printer components. Clarity in this subject provides value for spatial design, operation and installation.

Highlights

- Regardless of site dimensions and printer configuration the Y1 beam and Z1 column are always used as the main references for placing additional elements around the printer.
- The printhead “front” is where the hopper has an opening.
- The origo, also known as origin, is where all values (X, Y, Z) are 0.00 and is always placed in the printhead “back” on the opposite side of Z1.
- The Z-lower plate in the mounting area where the Z- column and the Y-carriages connect are also positioned with a specific intention, where the longest side of the plate and column are parallel to the printable area.
- The Operational Stand (OS) hosts the dosing system and should always be located relatively near Y1 truss where the MDS batch plant operation panel is placed so operators communicate properly.
- Note how the advanced hose management system (AHMS) starts from the Y1 inlet into the Z1 column and then runs the X-axis while the C-chain loop is located towards the Z2 section.
- The material delivery system (MDS) is placed in the middle of Y1 due to hose length.
- The printer comes with indicative stickers to make the component recognition process faster while offloading.
- The printer displayed above is a 5X-8Y-3Z in its configuration.

3. SYSTEM MEASUREMENTS

3.1 PRINTER AREAS



Definition

It is important to consider the general areas of the printer to optimize project dimensions and the correct use of space during the installation stage. Generally speaking, one concept will reference the installation area (IA) and another will reference the printable area (PA), these two concepts will be expressed in later measurement chapters as i or p. The printable area itself holds a cleaning space where the X-axis needs to be lowered every day to clean the printhead at the end of operations. Note the MDS will also have its own independent area in your project space as well as other operational equipment further stated in the *Site Readiness Checklist*.

Installation area (IA)

The minimum three-dimensional volumetric space required by the printer to be installed.



Printable area (PA)

The maximum space where your building can be printed.



Cleaning area (CA)

This space is left for lowering the X-axis down to ground level to clean at the end of each day. It is typically placed in one of the ends of the printable area, but it can also be placed anywhere inside if it does not intervene with your building plan.

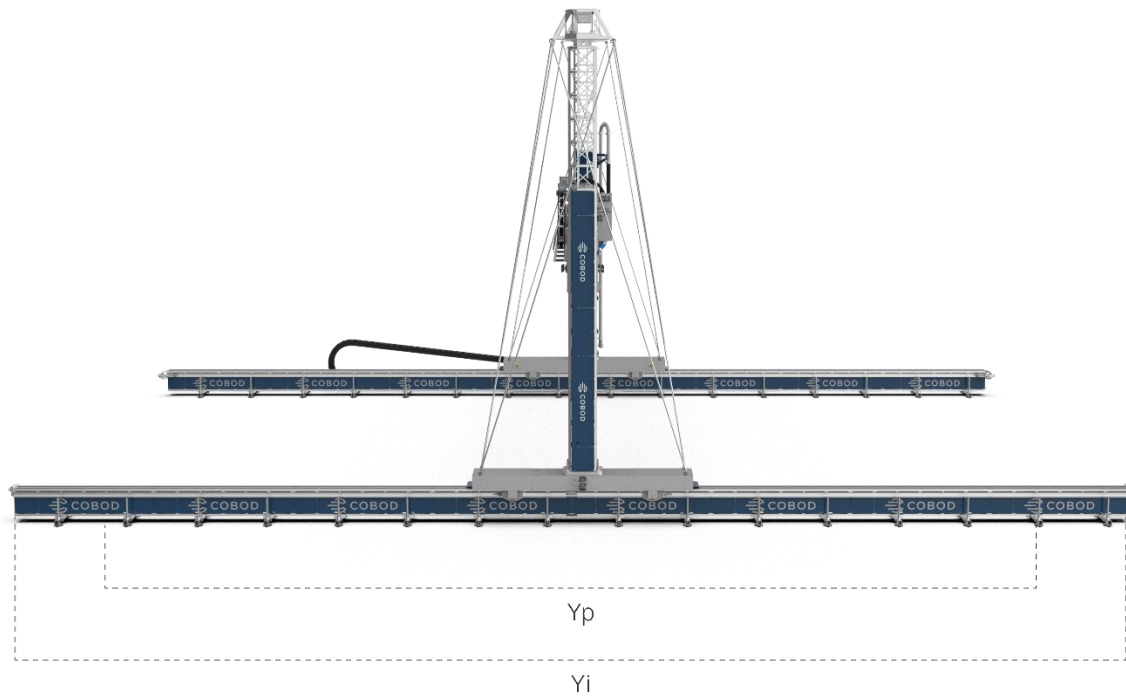


This last scenario would need to be coordinated during the design stage of your project.

The cleaning area should be minimum 730 mm on the Y+ direction or Y- direction (specific to site conditions).

Ultimately, it is the printer operator's responsibility (PO) to ensure intended designs fit to be properly printed inside the printable area. All areas and measurements are subject to site specific conditions and should be confirmed physically on site before starting operations.

3.2 Y-AXIS MEASUREMENTS



Modules	3	4	5	6	7	8	9	10	11	12
Yi (mm)	9436	11961	14487	17013	19539	22065	24591	27116	29642	32168
Yp (mm)	3502	6028	8554	11079	13605	16131	18657	21183	23709	26235

Definition

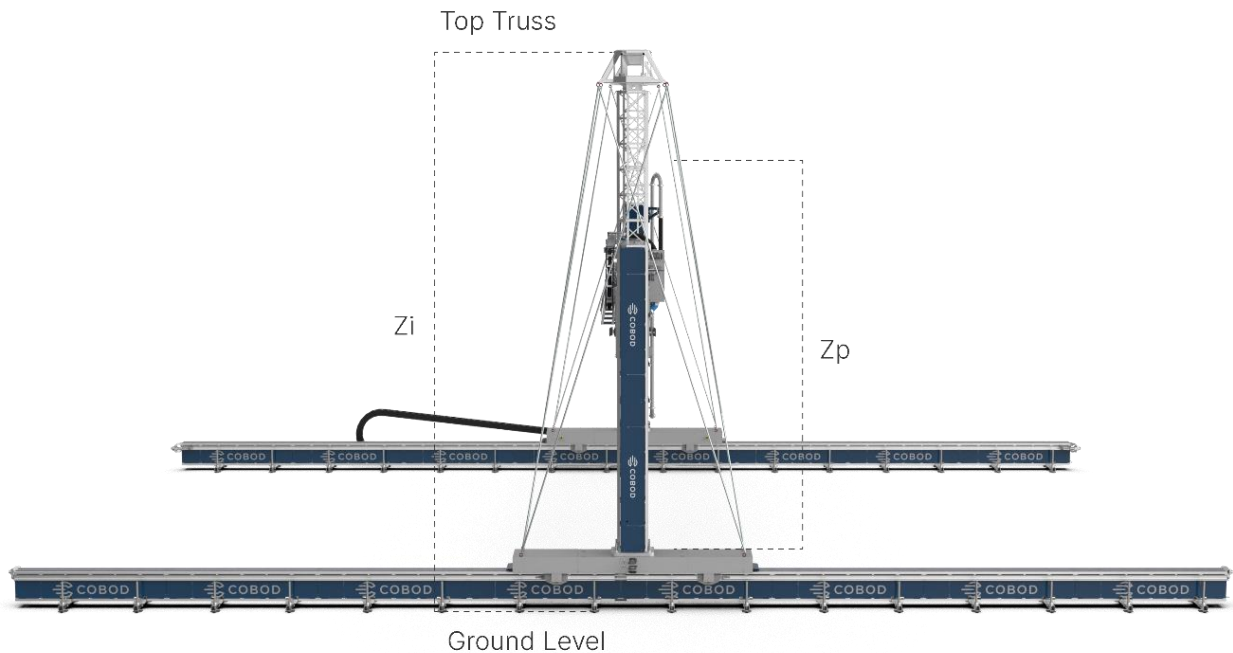
The Y installation area (Yi) is the total length of the printer.

The Y printable area (Yp) is given by the number of modules of the printer configuration.

Highlights

- Ys are installed first, hence the importance of understanding all parameters and variables.
- Print area in the Y-direction is given by the number of modules of the printer configuration and is NOT affected by site specific variables.
- Remember to add driving plates, crane pads or concrete slab edge dimensions in accordance with your surface type selection.
- Yp has the cleaning area (730 mm on +Y direction) deducted already.

3.3 Z-AXIS MEASUREMENTS



Modules	2	3	4
Zi (mm)	6714	9240	11766
Zp (mm)	3232	5758	8284

Definition

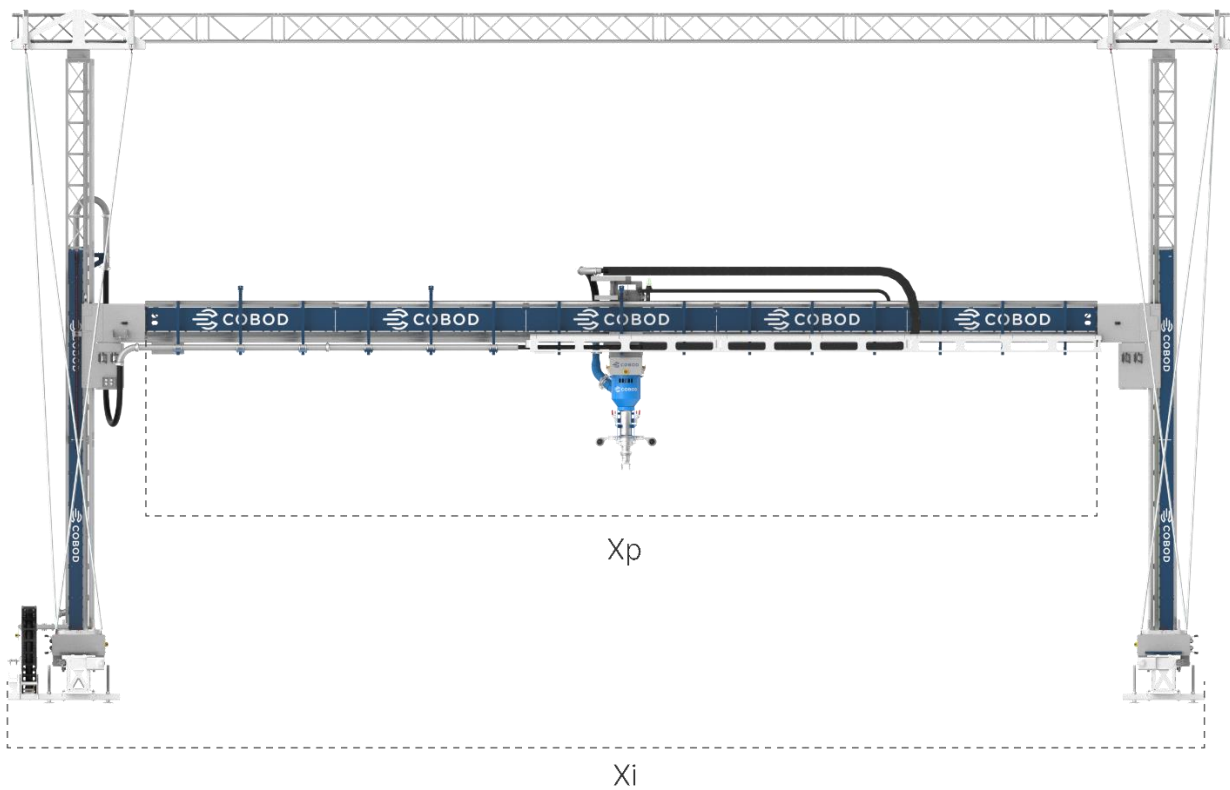
The Z installation area (Zi) is the total height of the printer (including mounting system and top structure).

The Z printable area (Zp) is the total height of the printable area, as high as your printed element can go per configuration once the printhead is positioned all the way up.

Highlights

- Mounting system refers to adjustable feet, crossbeams and driving plates (or any other mounting system type).
- Print area (Zp) is given by the number of modules in the printer configuration but is affected by site specific variables such as: the adjustment of the feet, the height difference between the printer mounting surface and the print area surface.
- By adding the height of the mounting system (the distance that the Z-baseplate is elevated of the ground) to the Zi-value, the total height of the printer can be calculated.
- Having proper clearance above the printer area for machinery such as a crane or a telehandler also needs to be considered.
- Measurements may vary depending on site conditions, if you are planning to use the maximum measurements, please contact techsupport@cobod.com
- If your configuration is 3Zs or above, a top structure will be mounted to increase rigidity of the system at height.

3.4 X-AXIS MEASUREMENTS



Modules	1	2	3	4	5
Xi (mm)	6643	9169	11695	14221	16747
Xp (mm)	1802	4328	6854	9380	11905

Definition

The X installation area (Xi) represents the total installation width of the printer, and it is taken from the outer most reach of the mounting system.

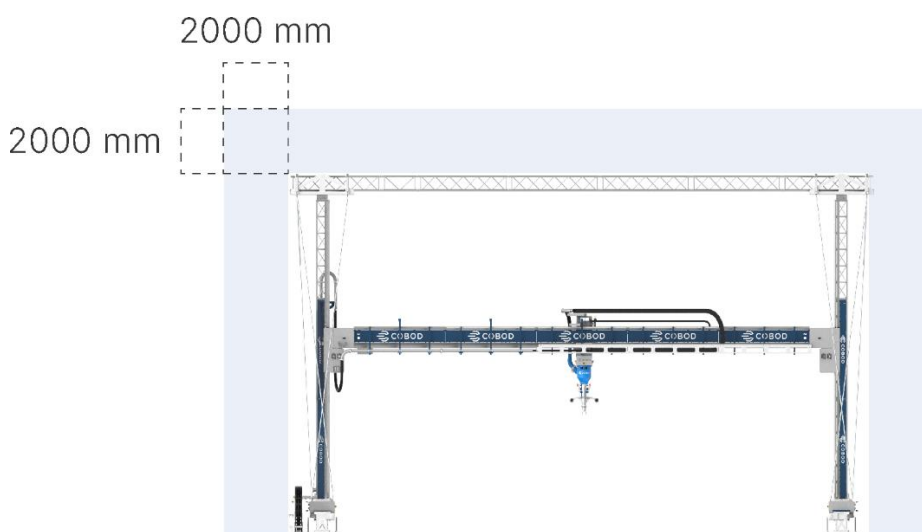
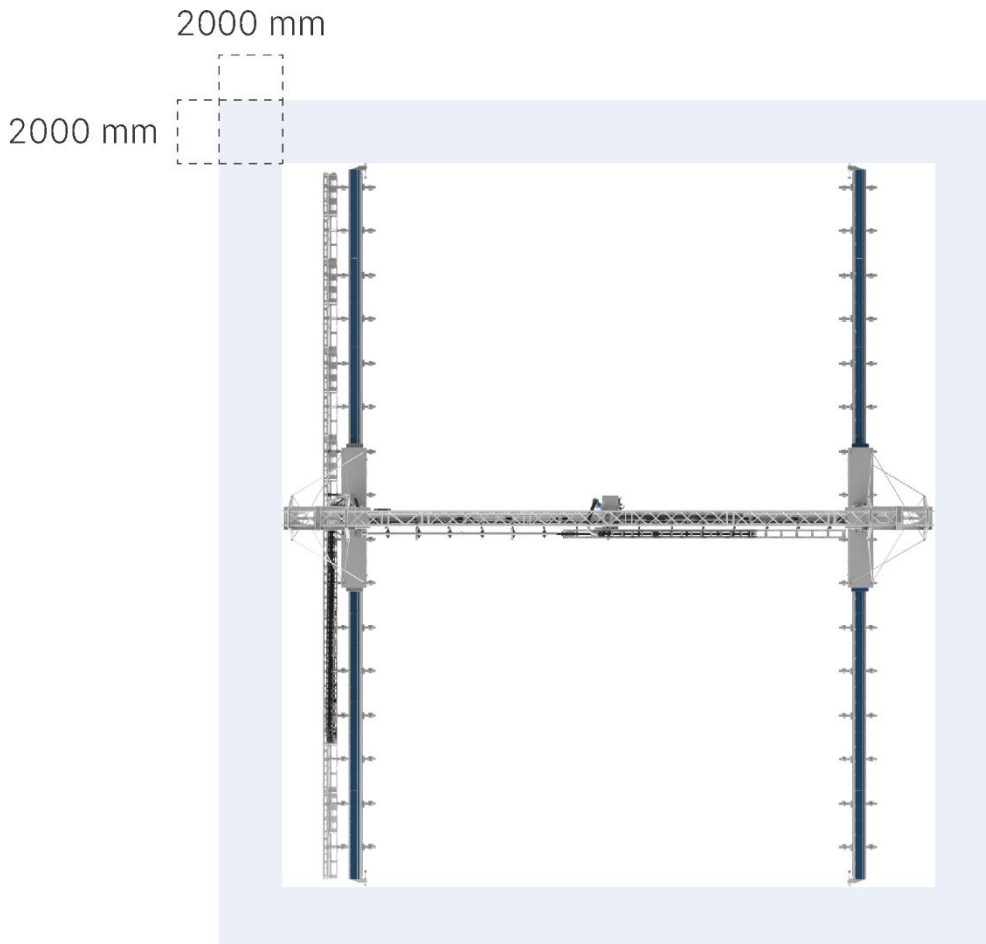
The X printable area (Xp) represents the maximum printable width of the element to build.

Highlights

- Print area in the Xp direction is given by the number of modules of the printer configuration and is NOT affected by site specific variables.
- Remember to add driving plates dimensions in case you are in contact with soil directly.

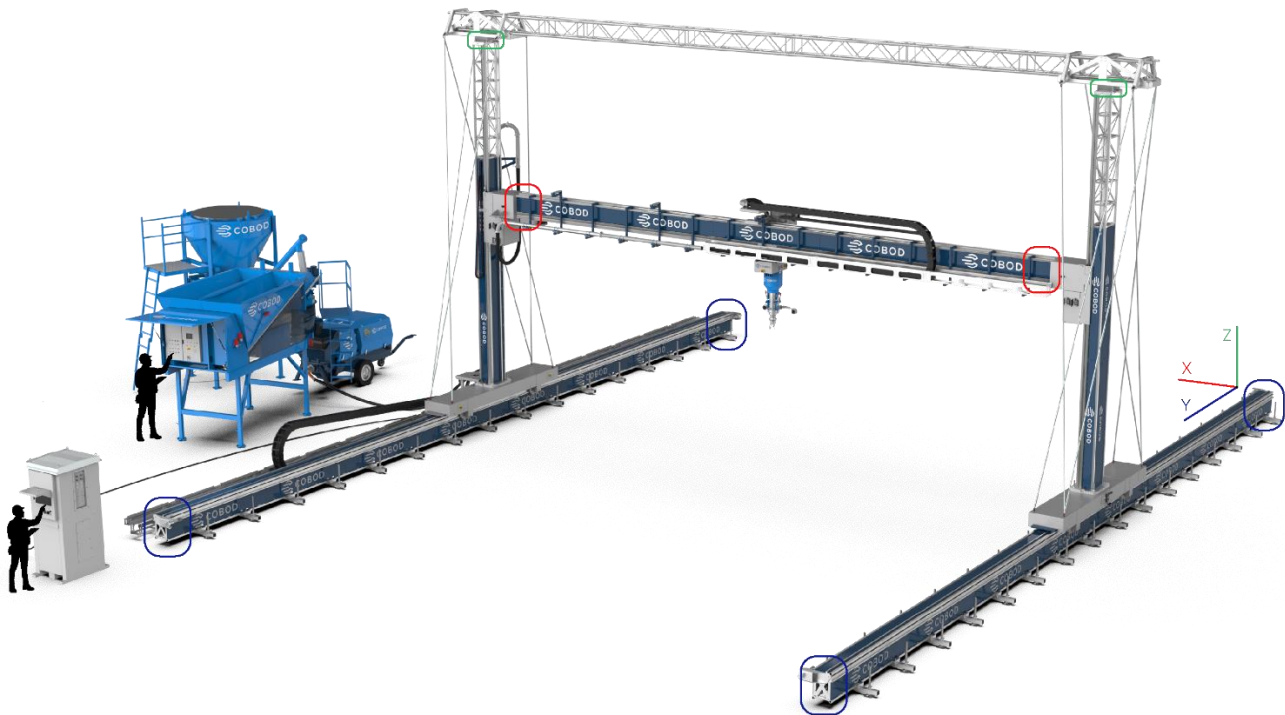
3.5 RECOMMENDED SAFETY PERIMETER

Having clearance around the outer dimensions of the printer is important for installation and operation. We recommend having 2000mm of space around the outer dimension of the printer to allow machinery and personnel to move around.



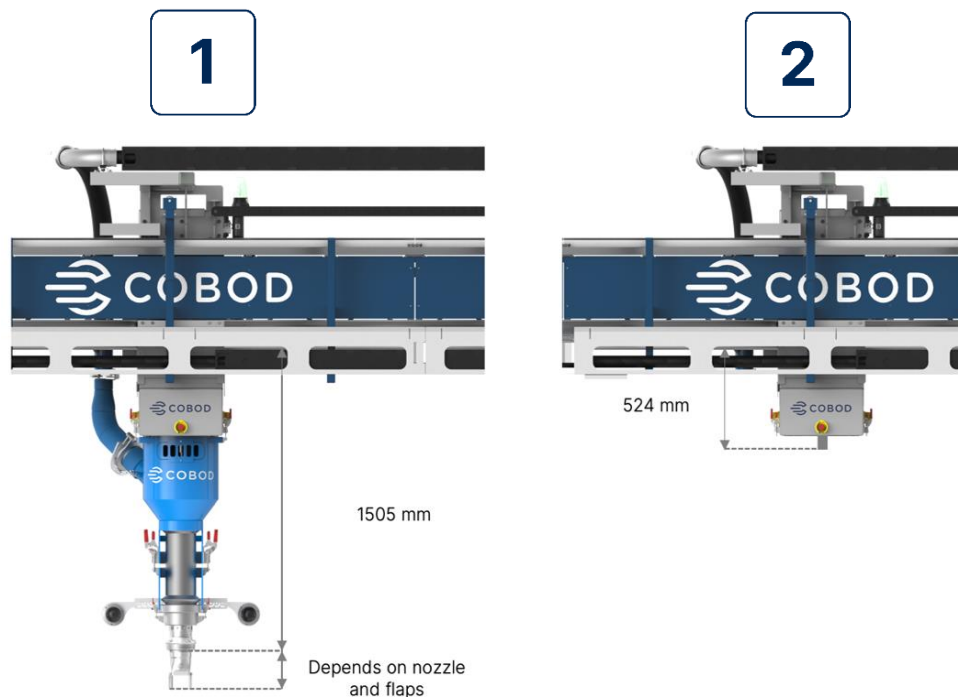
3.6 SAFETY LIMITS MAP

Below is a graphic representation of the operational limits per axis.
It is important to understand them during the project design stage.



- For the X-axis consider 100 mm at each end.
- For the Z-axes consider 50 mm above the bolts on the base plate.
- For the Y-axes consider 260mm per side (the shock absorbers).

3.7 CONSTANT MEASUREMENTS



Constant measurements are universal to all BOD3 printers, no matter the configuration.

The dimensions can be used to plan more complex printing objects – e.g., printing a building in multiple parts, to match ideal layer time goals (material related) or for loading/off-loading operations. The image above shows:

- 12.** The distance from the bottom of the X-axis truss (behind the tray) until the nozzle attachment – please note that the dimensions will vary depending on the nozzle and flaps used after that mark.
- 13.** The distance from the bottom of the X-axis truss (behind the tray) to the bottom of the X-carriage (incl. space for the screw connection piece). This is relevant when moving from site to site and planning top reach in a project design.

3.8 SITE READINESS MEASUREMENTS

During online training (Level 1) a specific site layout needs to be created to include the equipment in the context of your space, the layout covers topics such as:

- Mounting system location.
- Printer placement and orientation.
- MDS placement and orientation.
- Utilities.
- Waste disposal.

It is important to note that all projects (independent from the equipment) should have a risk assessment on the printed element itself. Further information can be found in the *Site Readiness Checklist*, for any additional questions please contact techsupport@cobod.com

4. MECHANICAL COMPONENTS

Please take a moment to review the *3DCP System Overview* section of this document before starting the chapter. The explanation of mechanical components will follow the installation logic:

- General concepts
- Y-axis
- Z-axis
- X-axis
- Z-connection system
- Dual dosing system
- AHMS

4.1 GENERAL CONCEPTS

4.1.1 MODULES

The flexibility and adaptability of the printer mainly resides in the fact that it is highly modular. Each printer model indicates size configuration: e.g., BOD3 4-5-3 will have 4 X-modules, 5 Y-modules and 3 Z-modules on each axis.

Each module is approx. 2.5 m long. The modules are aligned using fishplates and connected by four M16 bolts. Any printer can be set up in a smaller configuration than it was originally built by simply removing modules and rolling up the additional cable. Extending the printer would require new, longer E-chains (see the *Electrical* section of this document), cables and hoses for the AHMS.

4.1.2 AXES, BEAMS AND TRUSSES

A group of modules together create a beam or truss.

When we speak about movement X, Y and Z follow the Cartesian logic of axis, E and U are independent rotational functional items also referenced as axes in the operational interface and further described below.

4.1.3 CARRIAGES AND BOXES

X, Y and Z contain carriages to manage movement. Separately, the BOD3 has two hollow boxes connecting the Z-carriages to the X-axis, when troubleshooting it is important to know the difference between actual carriages and hollow boxes to communicate properly.

Carriages are both mechanical and electrical and it is very important to learn their location, characteristics, and names. A more in-depth explanation is shown in the *Electrical Components* section of this SOP.

4.1.4 KEYS

The BOD3 comes with the two sets for each of the following keys plus a COBOD Keychain:

Start-up key

Located at the Operator's remote control, the start-up key is the first step in powering on the machine after soft N/A opens.

In case the physical key is lost, startup can also happen from the "settings" tab using the "I lost my key" button.



Safety override key

In the rare event of having to override the safety system this can be done by inserting the supplied key and turning the switch.

⚠ Attention: The safety override key should only be engaged only when instructed by a COBOD service technician.



Moving the machine in safety override mode can result in severe damage to the machine and potential safety risk to personnel on site.

Operator Panel

Opens the metallic cover protecting the HMI screen, the cabinet, and the back cabinet to access the dosing system pumps.

Both should always be closed to prevent humidity from getting in, especially during transportation and storage to prevent damage.

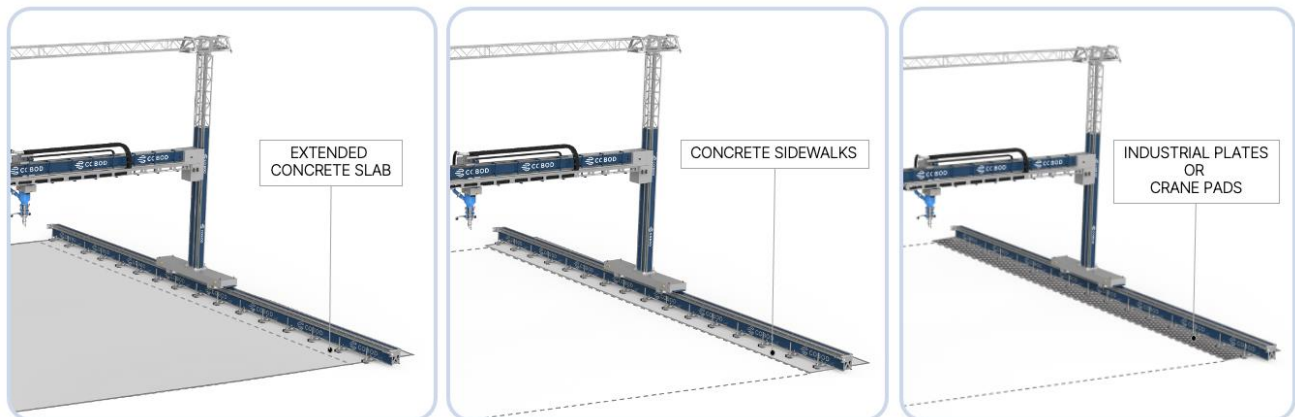


E-boxes

Opens electrical boxes such as the XUC (X-Universal Carriage) for maintenance inspections and/or troubleshooting.



4.1.5 SURFACE TYPE FOR MOUNTING SYSTEM



Definition

Printers need to be placed on top of a stable surface to safely operate. These surfaces can be either concrete slabs, concrete sidewalks, driving plates or crane pads. All options should be considered by the budget, type of soil and its loading capacity, evenness of ground and project specific goals. Regardless of your final selection, industrial/driving plates are included in your shipment.

Ground levels

Having a level surface is important to maintain a safe operation. Always consider the full weight of your printer and MDS when analyzing site soil conditions, ensure overall dimensions and placement information is available for your surveyor before starting earthworks. In case the installation site has different levels ensure they do not surpass tolerances or execute a level compensation strategy in accordance with your project manager.

Ground compaction

Soil should be leveled and, in some cases, compacted according to the specific soil type to prevent equipment from sinking. If concrete slabs or concrete sidewalks are chosen concrete specs should be min M15 grade. If crane pads are chosen soil requirements are 200 kN/m². Soil deformation due to rain, columns sinking, and misalignment might occur if soil compaction is disregarded.

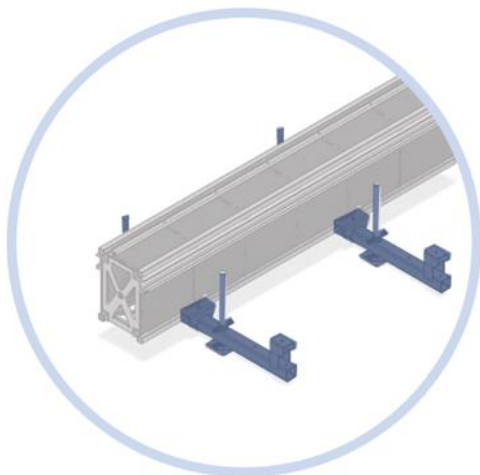
4.1.6 MOUNTING SYSTEM

Definition

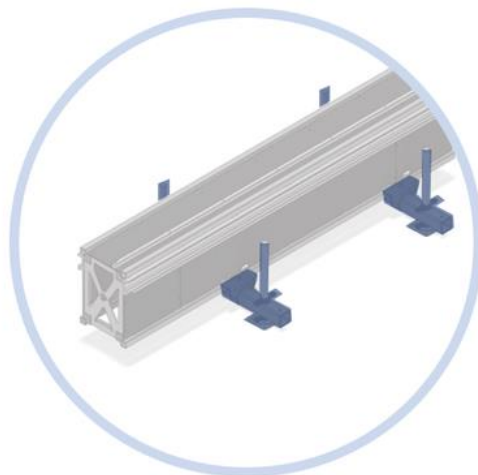
Printers are installed on top of a mounting system; this system involves scaffolding feet (vertical elements) and crossbeams (horizontal elements) which are placed on top of a selected surface and never directly into soil (as seen in the previous chapter).

Highlights

- Crossbeams are different between Y1 and Y2.
- Scaffolding feet have a dynamic range tolerance of 300 mm.
- Y1 crossbeams are longer and host a tray to support the AHMS.
- Y2 crossbeams are shorter, therefore, faster to install.
- Scaffolding feet are fastened through crossbeams, threaded rods, foot plates and a nut.
- An exploded infographic is provided later in the document for a more detailed breakdown.



Y1
MOUNTING SYSTEM



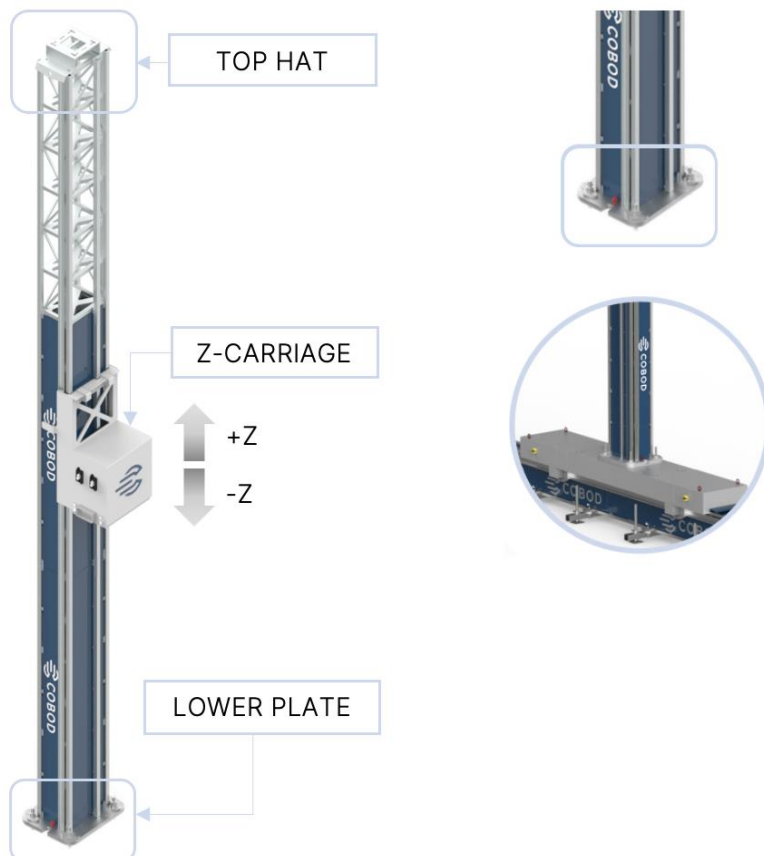
Y2
MOUNTING SYSTEM

4.2 Z-AXIS

Definition

Z-axes are the vertical components of the machine and are sometimes called columns. There are considerations for these items in the top (such as clearance when installing) and bottom, (such as the mounting system mentioned above).

As described in the *Printer Components* section, Z1 is the main column and holds specific electrical components.



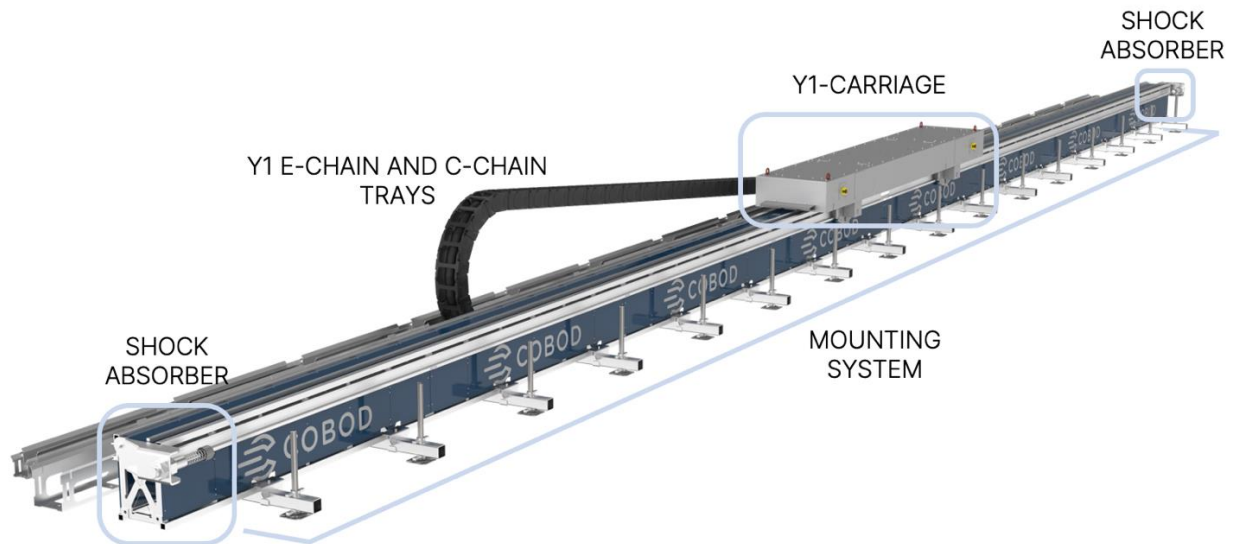
Highlights

- Z-axes can be assembled of 2 to 4 Z-modules.
- All Z-modules in the BOD3 require an additional Z-Connection System (ZCS) frame for stability.
- Each Z-module has 2 rails, 1 tooth rack and one attached cable chain.
- Z-axes can be extended without additional cables.
- Z-axes can be identified by the lower plate and top hat.
- Z-modules have larger tooth racks than X- and Y-modules which makes them heavier.
- Z-axes lower plate connects to Y-carriages.
- Z1 is different from Z2 in the Z-carriage electrical components and connections.
- Z1 is different from Z2 in the AHMS vertical pipe installation.
- Configurations of three Zs or higher require Dyneema ropes, alu truss system and T-brackets.

4.3 Y-AXIS

Definition

Ys are the first installation component placed on top of the selected surface and host the Z-columns on top of the Y-carriages that will slide back and forth during operations.



Highlights

- The Y-axis is represented by two beams called Y1 and Y2 in a BOD3 printer.
- The image above shows a Y2 beam, identifiable by a short crossbeam while Y1 hosts a long mounting system.
- Each Y has a shock absorber in each end as a mechanical failsafe protection.
- Ys are moved in groups of 4 modules at the time, if wheel jacks are used.
- Y-carriages eventually hold Z-columns and slide back and forth during operation.
- Y-beams are assembled of 3 to 12 Y-modules (+ unlimited length when you move them).
- Ys are never placed directly in the floor, instead, they rest on top of a mounting system that is different between Y1 and Y2 called the mounting system.
- Y-modules can be moved from one end to the other to slide the printer.
- An even floor is needed for the Ys to distribute loads uniformly. Please reach out to techsupport@cobod.com for site variables and tolerances.
- Ys have small tooth racks and are the lightest of all axes without the mounting system.
- Y1-carriages differ from Y2-carriages in the number of E-stops and plugs.

4.4 X-AXIS

Definition

The X-axis holds the XUC-carriage and printhead, however, it also holds empty ZX-boxes on each end. Due to the vast majority of components, the X-axis is the most delicate of all axes during handling and should be transported and installed with care. Upon reception, the XUC-carriage will be packed individually, the axis is usually transported in two parts and recognizable by the attached ZX-boxes on each end.

Take a moment to familiarize yourself with the components described below:

TOP VIEW



ANGLE FRONT VIEW

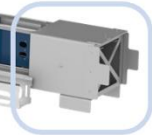
ZX1-BOX



XUC-CARRIAGE



ZX2-BOX



PRINthead



FRONT

BACK

Highlights

- The X-axis is typically assembled of 2-5 X-modules.
- Company logos are typically displayed on the X-modules with one logo per module.
- Each X-module has 1 tooth rack, 2 cable trays (inside/outside) and 3 rails.
- X-modules/axes must always be placed in stackers to protect the tooth racks underneath the modules when handling.
- The X-axis hosts a ZX-boxes in each end that are rests on top of Z-carriages.
- The XUC-carriage hosts the printhead where material is further mixed and extruded.
- X-movement is referenced to the Z1 column, for further information on the way the X moves please review the *Printer Movements* section of this SOP.
- The printhead hose inlet of the printhead is always placed on the side towards the Z1 column.

4.4.1 LIGHT ON X-CARRIAGE

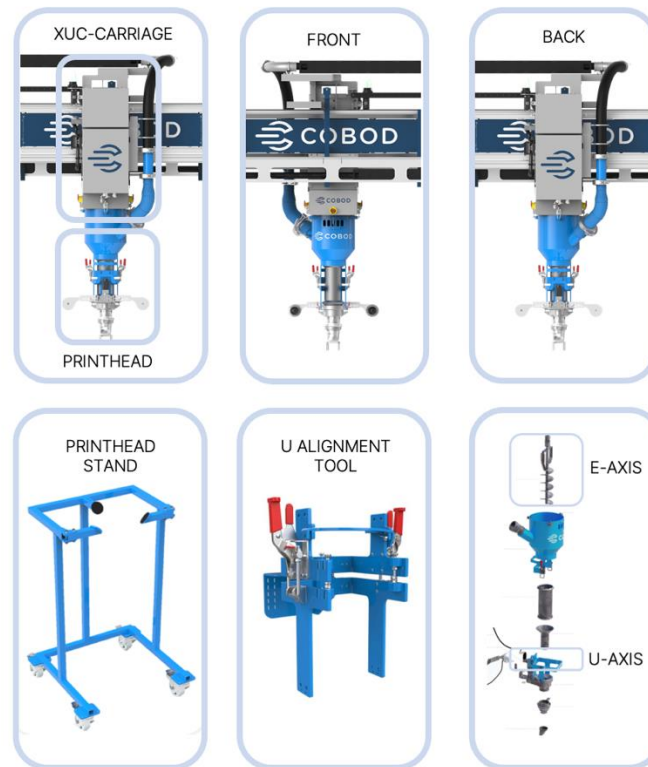
The signal lamp above the X-carriage indicates the operational status of the printer.

Solid Green: Printer is ready to have drivers engaged. No errors. Material sensor indicates ABOVE MINIMUM to FULL (depending on value set in PLC).	
Solid Red: Drivers not engaged (can be missing key rotation, error needs troubleshooting, error reset or green start button was not clicked).	
Blinking Green/Yellow: Printer has drivers engaged or is. ready to. No errors. Material sensor indicates BELOW MINIMUM (depending on value set in PLC).	
Blinking Green/Red: Safety override key is engaged. ⚠	
Yellow LED blinks slow: Concrete/mortar pump is pumping.	
Yellow LED Blinks fast: Piston pump reversing	

4.4.2 PRINTHEAD ON XUC-CARRIAGE

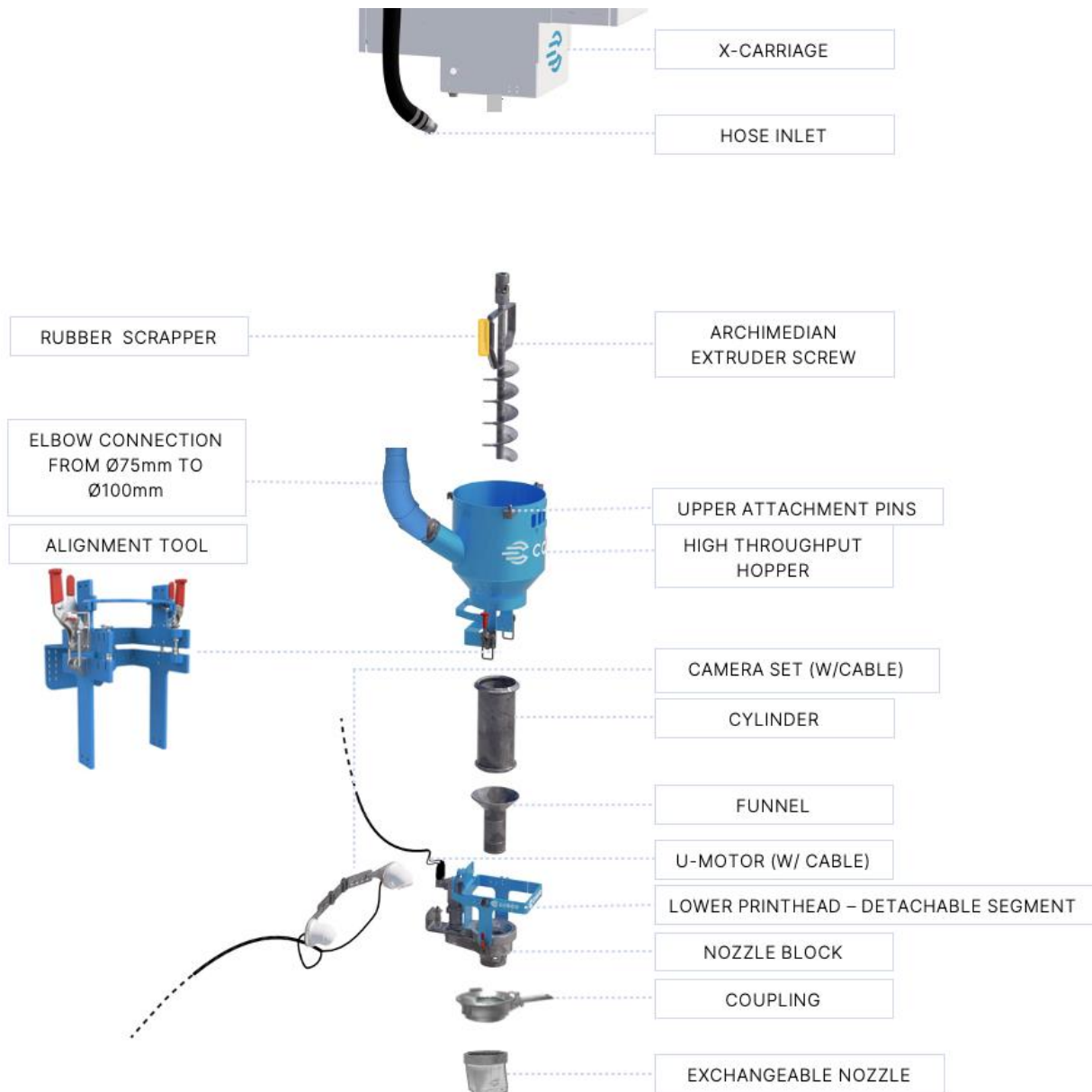
Definition

The printhead (also known as the “extruder” in plastic desktop printers) is located on the X-axis and it is mounted/dismounted from the XUC-carriage.



Highlights

- Material typically flows from the hose into the hopper and out the nozzle.
- The printhead holds both the E-axis (extrusion) and U-axis (360° rotation) within.
- The printhead is highly modular and has direct contact with concrete, due to this, is essential to learn all its part names, handling procedures and proper maintenance.
- The printhead is mounted and dismantled each day after printing operations, when the hopper is dismantled, the XUC carriage and concrete hose are left behind.
- A stand comes with the printhead for moving, storing, holding during cleaning and mounting/dismounting support.
- The U alignment tool displayed above is a key component of the printhead assembly ensuring the set-up is fully vertical (90°) when mounted. Proper alignment allows material to flow uniformly and ultimately reflects layer quality especially relevant in curves.
- Statistically, the most common error is to pull the U-cable when dismantling the printhead at the end of each operational day, to prevent this, ensure the printer is off, safety chain link is on and all cables are disconnected before proceeding to clean.
- The grid in the hopper opening should always be installed.
- A more detailed infographic shows each component below:



4.4.3 NOZZLES

Definition

The nozzle defines the width and height of the wall.

It is the mechanical end of the printhead where material is extruded and walls are formed, it is exchangeable and customizable.

Choosing the correct nozzle shape and size is important for material cost, printing performance, architectural design, and overall structural integrity of the printed element during the planning stage of the project.

Location in system



Included in purchase

Your 3D construction printer comes with two, squared shaped, stainless-steel nozzles that are threaded for easy manual installation.

Under special conditions, customers can decide to create their own nozzles in which case we recommend 3D print prototypes with TPU or ABS filament. TPU results vary on the selected color and ABS tends to break after a couple of tests due to concrete. Plastic prototypes tend to decay in time and might not last an entire print affecting also final results for surface finish. COBOD is not responsible for the development of independent nozzles nor their performance in final prints.

Location/Orientation

Nozzles are installed in the printhead and have two sides; the front of the nozzle has a flat horizontal edge while the back has a zigzag or “teeth” pattern to ensure better adhesion with consequent layers when depositing material, validating material consistency and help in multi-day printing for bonding between layers.

Installation

Nozzles are threaded all the way into the fitting and installed by hand with simple rotation. Two half-moon shaped tools are provided to tighten the nozzle in place.

Use

They are used at the beginning of each print day and removed for cleaning at the end.

Nozzle rotation is controlled by U-axis movement, which can be done by the HMI interface or Duet interface dashboard.

Responsibility

Since the nozzle has many implications during printing, the selection of its shape and dimensions are a shared decision between the PO, MO and PM.

When choosing the correct nozzle, you should consider the following:

- Size of hose (material aggregate size).
- Layer height to nozzle width ratio.
- Desired wall texture (resolution).
- Length and location of flaps (if any).
- Radius of corners in your design.

Transportation, storage, and care

Nozzles are generally robust, keep them clean after each print day for optimal use.

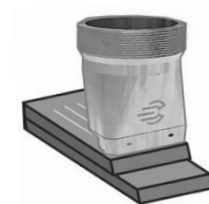
Models



Orientation



Use



Best practices

- Do not disregard the importance of choosing the right nozzle for your geometry to obtain the expected surface quality results from an early stage in your project.
- Keep the bolts mounted inside the flap attachment holes to prevent it from being filled with concrete.
- Always consider local regulations regarding minimum wall thickness when choosing your nozzle.

4.4.4 FLAPS

Definition

Flaps are small metallic accessories mountable to the sides of the nozzle to improve the surface finish as well as assist in controlling the width of the printed layers.

See visual comparison of layers printed with flaps and without flaps. Usually, printing without flaps produces more rounded layers that potentially consume more material.

Included in purchase

Four pairs of flaps are included in your nozzles with the measurements displayed on the right.

10 mm: Typically used for the first layer.

40 mm: Typically used for one layer (assuming 40 mm layer height).

80 mm: Typically used for two layers (assuming 40 mm layer height).

100 mm: Graded so customers can cut into the size they might need.

Location/Orientation

Flaps are manually attached to one or both sides of the nozzle depending on the desired texture. When printing next to wall binders or any other type of reinforcement a carefully selected flap should be considered to prevent impact.

Installation

The nozzle has threaded entrances for M4 bolts so flaps can be installed by a #3 Allen key and their shape is intuitive for placement.

Use

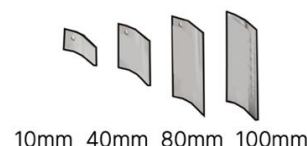
Flaps are manually installed after the first couple of layers when the nozzle is placed at the right height, clearing from any potential collision with foundation structural elements.

When starting a new layer on top of a previous print, small flaps should be considered. Longer flaps might impact hardened concrete from the previous print and trigger collision.

Location in system

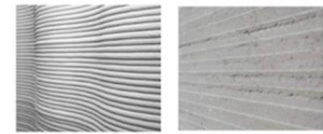


Sizes



Using or not using flaps will impact the texture of your wall and depends on your project design specifications. There is a variety of flaps to choose from depending on surface quality goals, the size of objects you are printing and the material.

Layer texture



Round edges

Flat edges

Responsibility

The PO is responsible for transporting and installing the flaps on a daily basis.

Transportation, storage, and care

It is common to forget the flaps when you are moving inventory, so we recommend deciding the flap model in advance and installing it into the nozzle when packing.

Best practices

- Set the right flap length parameter when slicing the geometry in COBOD Slice. Otherwise, you will cut your print!
- Remember to install the flaps whenever the height allows for it.
- Define the inside/outside of the wall when doing single flap printing to prevent wall cutting. This consideration should be defined and virtually simulated in the slicer.

4.5 Z-CONNECTION SYSTEM

Definition

The BOD3 connects Z1 and Z2 through an upper tensioning system that provides stability during operations, and it's required in all Z configurations 2-4. Complementary to the connection system there are additional vertical tensioning ropes called Dyneema ropes that are also required for Z configurations of 3 modules and above. Included in purchase.

The number of modules and ropes in the system will correspond to the specific printer configuration that was purchased. If you intend to change your configuration, please contact: techsupport@cobod.com for additional information.

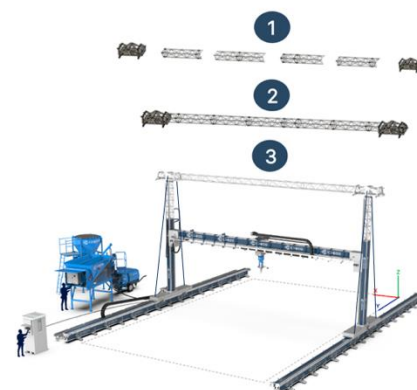
Location/Orientation

The system is located at the top of the printer, where Dyneema ropes are used, and it connects with Y-carriages in the bottom.

Installation overview

The system comes dismounted in several parts and needs to be assembled on the ground and then mounted and secured into the printer.

To properly install the system at the top, a cherry picker and a crane are required to ensure safety.



4.6 SAFETY FEATURES

Definition

The following section expands on the multiple safety features offered by the equipment to promote a safe operation. It is important to understand these components to perform the appropriate maintenance checks and ensure they are correctly working at all times; any anomaly should be reported to techsupport@cobod.com for assistance.

Responsibility

Site and operational safety must always comply with local regulations and site-specific conditions. Site managers/Project managers are ultimately responsible for always preparing and maintaining a safe operation with the PO and MO crews.

Best practices

- All personnel are expected to read this document in full before performing operations.
- Confirm the printer operator (PO) has successfully passed COBOD's professional training Level 1 and 2 and is in possession of a valid PO certificate. Printer use by non-certified personnel is not allowed and can compromise safety. Additionally, any equipment harm performed by non-certified personnel will void warranty.
- Ensure that separate areas for the operational teams and potential visitors are clearly marked on site.
- Make sure all operational personnel wear the appropriate personal protective equipment (PPE) when printing.



14. XUC collision clickers

Located in the connection between the XUC carriage and the X-axis, these components stop operation in case of a printhead collision.



15. Hopper grid

The grid prevents operators from inserting their hands inside the hopper, where the moving Archimidean screw is located.

The hopper grid must always be installed during printing operations.



16. Homing clickers

These clickers are sometimes also referred to as “positioning clickers” and are meant to indicate operating limits per axis, meaning, how far can the printer go in each direction. They are used during homing operations with the PLC. Homing clickers are a two-part component; one is the clicker itself located in the carriage and the other one is its homing trigger bracket in the truss.

More information is available at the Maintenance Section of this SOP.



17. Z-limit switch

Mounted on each Z-carriage, Z-limit switches stop the printer in case the X-axis is requested to move beyond physical possibilities of the Z-height through faulty installation or incorrect homing.



18. Hose to hose connections safety system

The system includes anti-whiplash cables and coupling safety pins for hose-to-hose connections.



19. E-stops

E-stops, or emergency stops, are safety mechanisms designed to quickly halt machinery or equipment in emergency situations to prevent accidents or injuries.

For more information on the specific location of these in the BOD3 printer, please see section *E-Stops Location* further down this document.



20. Audio-visual communication

A printing “signal lamp” displays 3 different colors and it is in the top section of the XUC carriage.

The printer can also trigger one prolonged sound alarm to indicate an error.



21. Error notification

Both operational interfaces are equipped with error notifications to indicate specific actions required by the user. A detailed error log is available in COBOD Connect for reference.

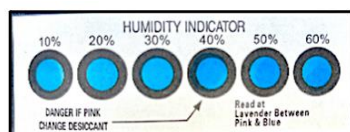


22. Humidity indicators

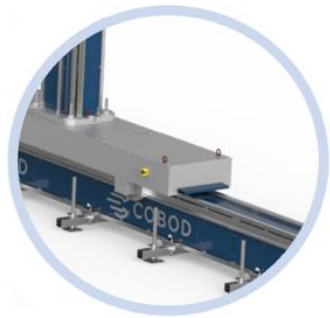
Carriages come with two silica bags (big bags) and one humidity indicator (small bag) to inform about potential moisture presence in the electronic compartments.

If the silica bags turn light yellow, or the humidity indicator turns purple, it means there is water in the carriage and further inspection/replacement is needed.

It can also indicate there has been humidity in the past and bags should be replaced.



Remember to perform humidity checks before powering the machine on. It is important to follow the maintenance recommendations from the Maintenance chapter to always ensure safe operations.



23. Inductive rail sensors

Located in the Y-carriages mounted on top of a bracket, these items will stop the machine in case the printer is moved out of the rails.

There are two inductive rail sensors per Y-carriage (four in total in the printer), each facing Y- or Y+ direction respectively.

The sensor moves along Y trusses and the bracket holding the sensor sticks out further out than Y-carriages. In case of being driven beyond the printable area, sensor will surpass the Y-truss and the machine will enter in error state, resulting in a complete stop.



24. Bumpers

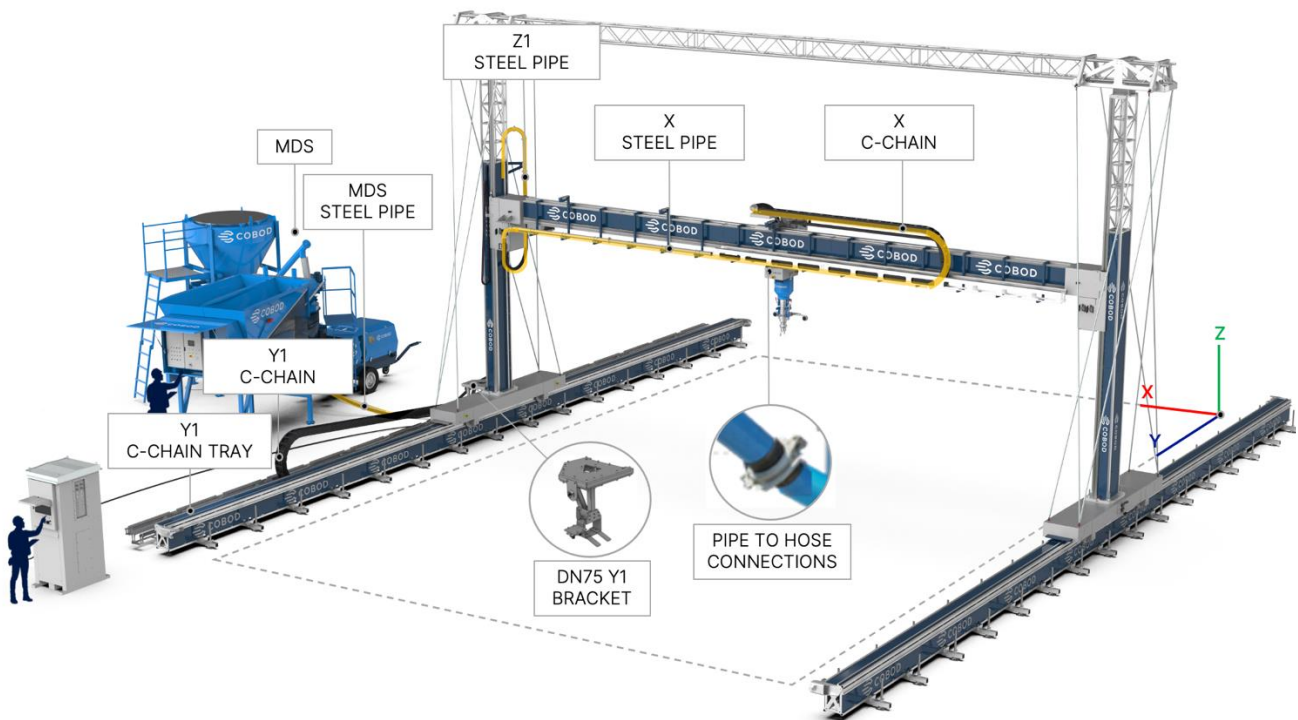
There are two bumpers per Y-carriage, each facing Y- or Y+ direction respectively. Triggering any will send machine to an error state and prevent it from moving until the obstacle is removed.



25. Shock absorbers

Y-axes hold shock absorber springs in each end that are used as a mechanical failsafe solution against crashes or Y-carriage derailments.

4.7 ADVANCED HOSE MANAGEMENT SYSTEM



Definition

The advanced hose management system (AHMS) is a set of modular elements that transport material from the MDS into the extrusion point at the printhead without the need of external equipment support or personnel.

Highlights

- The AHMS is in the Z1 section of the printer always close to the MDS.
- It is a modular system, and it is shipped with hose lengths specific to the configuration that was purchased.
- Customers are advised to know exactly how many hoses segments they have and their length to request spare parts correctly.
- It is imperative to understand all connection points between hoses and pipes to troubleshoot potential clogs accordingly.
- Hose length is also important for slurry management.
- The system is a combination of trays, steel pipes, hoses inside chains (C-chains) and safety connectors between the hoses. Steel pipes are fixed and exposed while concrete hoses are covered inside the C-chain and in constant movement.
- C-chains have its own tray in Y1 separate from the E-chain tray that hosts cables.
- The system starts at the AHMS Y1-INLET going up through the Z1 column and into the X-axis ending at the printhead connection. More information is available at the *Installation* chapter.

4.8 SAFETY CONSIDERATIONS: MECHANICAL

- Use appropriate personal protective equipment (PPE) when operating the machine.
- Monitor all loading and offloading operations to prevent dents or equipment damage during rigging. **Damage during rigging is the #1 cause of harm to the printer.**
- Keep working areas clean and well always illuminated.
- Do not, under any circumstance, sit on top of Y-carriages, printer beams, trusses or elements in the machine.
- Do not leave any tools on top of carriages or any other parts of the machine.
- Keep hands out of moving part areas such as: carriages, rails, tooth racks and printhead extruder.
- Always be aware of hose outlet, even more so when dealing with clogs. During a high-pressure event this could cause serious harm through backlash or sudden release of pressure.
- Beware of houses on the ground as tripping hazards.
- Create a perimeter with access control points and a separate hall for visitors. Visitors can sometimes block visibility between operators affecting productivity.
- Use proper construction signage.
- Be cautious of sharp corners along the axes and E-chain trays.
- Do not use the printer as a crane.
- Be aware of “low clearance zones” when entering print area (X-axis and AHMS).
- Do not remove or tamper with any of the safety systems on the machine.
- Do not run the machine if there is damage to a mechanical assembly or with alignment out of specifications.
- Stay alert when operating heavy machinery. Do not print while tired or under the influence of drugs/alcohol.
- Ensure workers are aware of potential hazards on the construction site and receive proper training on hazard identification, handling and emergency procedures.
- A safety and preparedness plan should be created by the GC including utilities and backup generators to ensure the printing process can continue.
- When operating in remote locations using water tanks, beware of running out of water which could affect cleaning operations and consequently damage the equipment.



5.ELECTRICAL COMPONENTS

Definition

Plugs, cables, carriages and other electrical components are vital for internal and external communication in the printer. Their correct identification, installation, and maintenance is important for safety and performance.

5.1 GENERAL CONCEPTS

Power cable

The BOD3 comes with a 32A power cable that connects to the OS in one end and a power distribution board on the other. The board is powered by a generator for printing/building in remote locations but could also be connected to the grid in warehouses or laboratories.

It is important to note that the electrical specifications for the power distribution board are handled during training through the *Site Readiness Checklist* and may vary slightly from country to country. For specific information on your machine please contact techsupport@cobod.com

Connection point



E-stops

Emergency stops, most known as E-stops, are in many different areas of the equipment and should always remain at close proximity from the operator's hand in case they need to be activated.

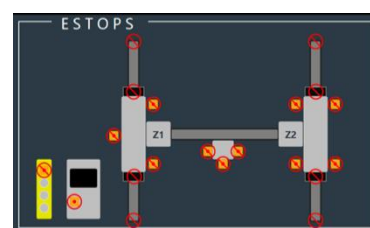
Rail sensors and bumpers are also registered as Emergency stops when triggered in the printer and are indicated as red empty caution circles in the interface.

Do not rely on the digital E-stop button in the Duet interface version 3.4.0, as described above printer operators should always be in close proximity to a physical E-stop.

Physical view



Digital view



Universal control box

This box is used during the installation stage to move carriages to a specific position, and it is not fixed to the printer after installation. The box is operated manually and should be connected to the carriage in one end through a Harting plug and to the power distribution box on the other.



E-chains

E-chains are used to manage and protect cables and additive hoses within the BOD3, ensuring a reliable and safe operation. Beware of pinches or stiff turns that could break the elements inside.



Operator remote control

This remote control is connected to the OS through a yellow cable and allows users to control certain actions from their working station. The cable is 20 meters long to consider for reach and is essential for powering on the printer.

Uses are:

A) Emergency stop

Allows an operational stop in case of emergency.

B) Manual pump material blue button

Allows to manually pump material since it sends signals to the COBOD pump.

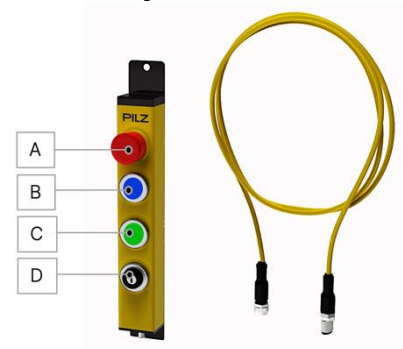
C) Safety verification green button

This button is used during start up or after error reset procedures.

D) Start-up key

The start-up key is the first step in powering on the machine after SoftNA opens.

Physical view



Connection point



Heavy duty sockets

The BOD3 has varying size electrical plugs, when requesting spare parts remember to specify if the part needed is the plug on the cable itself or the receptacle of a specific carriage.

Large versions are related with the main carriage communication while smaller versions are related with ethernet, E-stop connections and the connection of the dosing system.

To identify if a socket is an input or output, inspect the socket – if it has four pins it is a male connector (input) and if it has four holes it is a female connector (output).

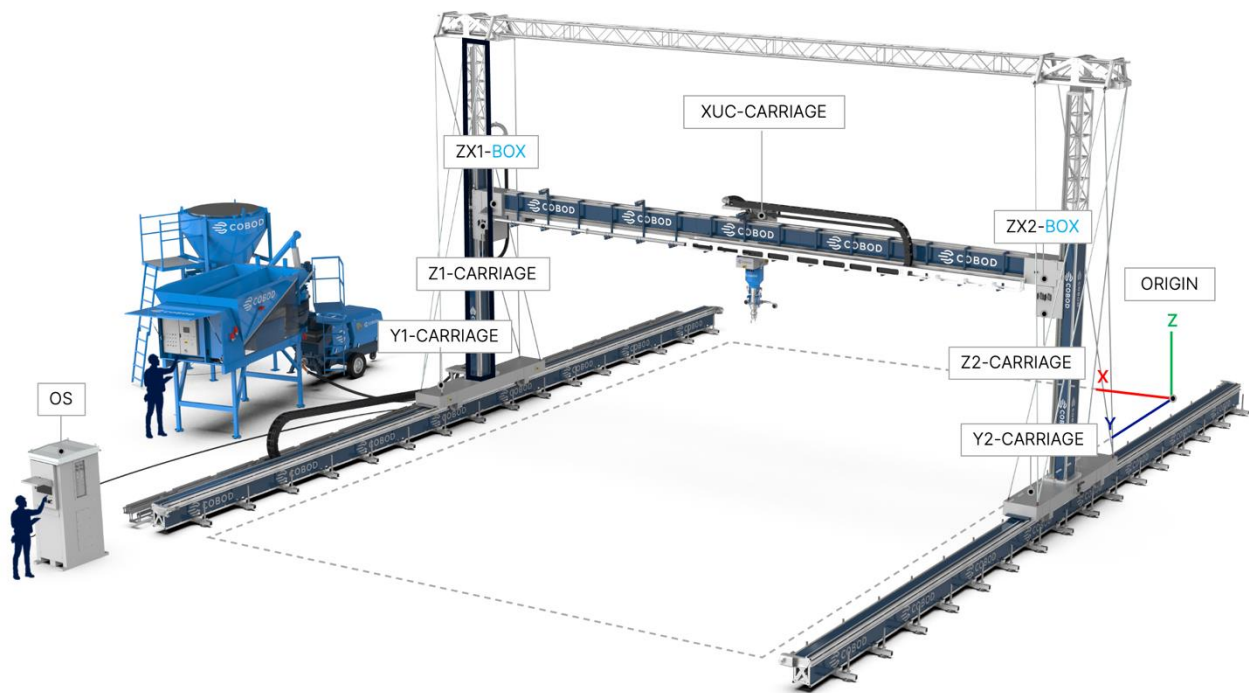
Pins reference:



*The wiring diagram is a representation of the male and female sockets above.

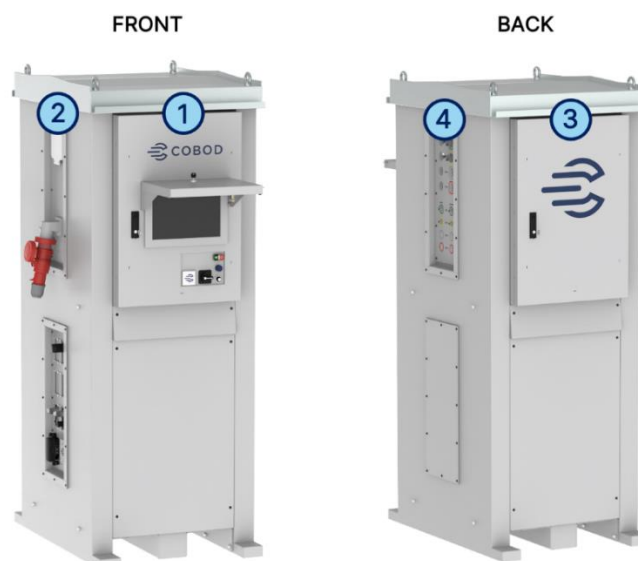
5.2 OPERATIONAL STAND AND CARRIAGE CONNECTIONS

Before expanding on the cables, it is important to recognize all the carriages, their appearance, and their specifications. This will make connecting the cables a much faster task. The image below shows the main carriages and boxes to consider.



Operational Stand

The Operational Stand (OS) has four sides, each one with multiple functions. Even if it is not a carriage specifically it works as one in some of its functions. It connects to the printer in the middle of Y1 and should be kept away from tripping hazard areas with a length ratio of 10 meters prioritizing visibility to the printable area.



Side #1 Operations

The front of the Operational Stand (OS) is equipped with an HMI touch screen interface, on/off buttons for high power, pump signal indicator/button, a sun cover, and a safety override key (for more information please review the *Keys* section above).

The main circuit breaker is located the front of the Operators Panel under the touchscreen.

Touchscreen

The printer is equipped with an IPC (Industrial Personal Computer) that runs the Soft-NA interface and can also run various other background operations. The IPC is operated using the built-in touchscreen.

Red/Green Buttons

The upper set of buttons are for arming and disarming the safety system. If any faults are present in the system this will not harm and therefore operation of the printer will not be allowed. When the safety system is armed the small light between the buttons will turn on.

Blue button

The blue button below has two functions. Firstly, it is an indicator of when the printer is requesting material from the material delivery system and will light up when material is needed in the hopper. Secondly, it functions as a button for manually requesting material (ie. Running the pump).

Safety override key

In the rare event of having to override the safety system this can be done by inserting the supplied key and turning the switch. The safety override key should only be engaged in certain situations or when instructed by a COBOD service technician.

Side #2 Connections

External connections on the Operational Stand exist in sides 2 and 4. Only the power cable and the operator safety remote are essential for powering on the printer.

We recommend physically tag all ports and cables so transportation from site to site and overall inventory is easier.

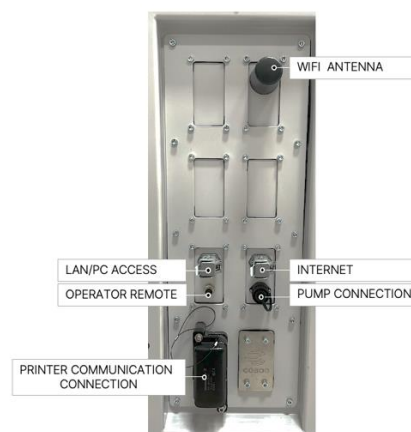
- **5G/LTE-ANTENNA**
- **PRINTER POWER CONNECTION:** This OS female plug connects to a 32A male plug in one end, the other end of the cable will connect to the power distribution board.
- **WI-FI ANTENNA**
- **LAN/PC ACCESS**
- **OPERATOR REMOTE CONTROL:** This connects to the yellow cable from the remote control to be used in the PO station.

Top part



- **PRINTER COMMUNICATION CONNECTION:** This plug connects to the Y E-chain male plug.
- **INTERNET**
- **PUMP CONNECTION**

Bottom part



Side #3 Dosing System

The Operational Stand is equipped with a dosing system capable of delivering up to four additives directly to the printhead, allowing for the simultaneous delivery of multiple additives.

For detailed information on installation, operation, cleaning, and maintenance, please refer to the Dosing System User Instructions.



Side #4 Dosing cable connections

This side manages level fill sensor connections, additive hose inlets and additive hose outlets. The chemical plastic containers will be placed on the floor next to this side to facilitate cable reach.



Color tags correspond to the hoses going all the way through the printer:

- Green is pump #1
- Yellow is pump #2
- Grey is pump #3
- Red is pump #4

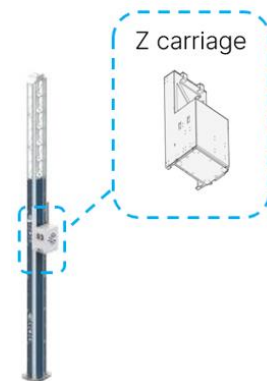
Y1 Carriage

- Comes mounted on Y-axis since shipping.
- Includes two E-stops facing toward the print area to make space for C-chain and E-chain rails.
- Utilizes “bumper” sensors to safeguard in case there are unwanted obstacles on top of Y-trusses.
- Has inductive sensors to prevent Y-carriage derailment.
- Electrical input/output connections face away from printable area.
- Y1 has 2 plugs, one input and one output. The input plug (male) is from the COBOD Operators Panel through the Y1 E-chain. The output plug (female) of the Y1 connects through the Z1 axis E chain into the Z1 input plug (male).
- Y2 Carriage
- Comes mounted on Y-axis since shipping.
- Different from Y1, Y2 includes 4 E-stops, 2 on each side.
- Utilizes “bumper” sensors to safeguard in case there are unwanted obstacles on top of Y-trusses.
- Electrical connections facing away from the print area.
- The Y2 carriage has two plugs on one side like the Y1. The input (male) is where the female connector of the “Z2-Y2” cable attaches while the output (female) is unused.



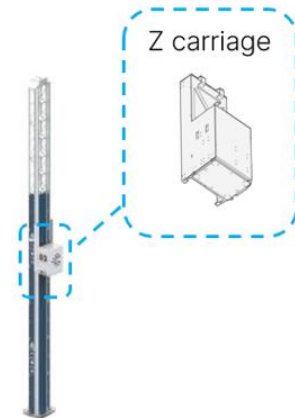
Z1 Carriage

The Z1-carriage is slightly different from the Z2 carriage as it has two output connectors, one more than the Z2. Two plugs face Y+ and one single plug faces Y- when installed. The plug that is by itself is the output (female) connection to the X Universal Carriage (XUC), so the male end of “Z1 – XUC” E-Chain connects here. On the other side with the two plugs there is an input (male), where the female end of the “Y1 – Z1” cable is connected. The third plug is an output (female) where the male connector of the “Z – Z” cable connects.



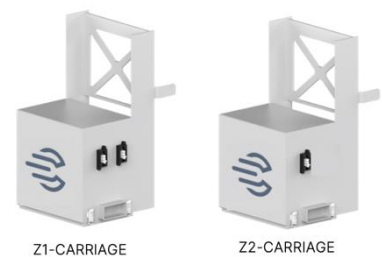
Z2 Carriage

The Z2-carriage only has one input and one output with two plugs on one side, but only one input connection is utilized. This input (male) is connected to female connector of the “Z-Z” static cable from the Z1.



Z1 and Z2 Differences

Z1 carriage has one extra plug (2 outputs and one input) while Z2 carriage has 2 plugs in total (1 input and 1 output).

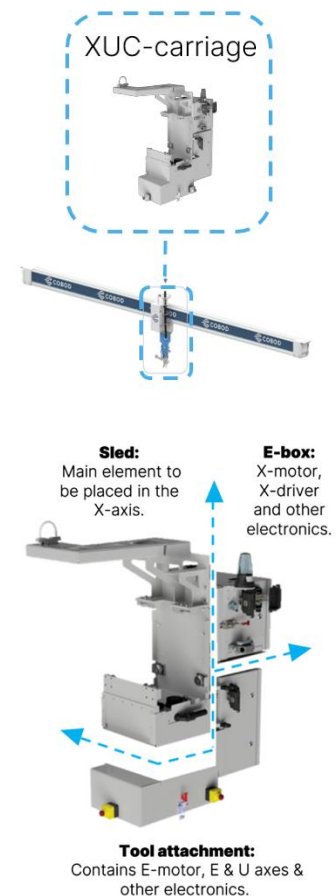


XUC Carriage

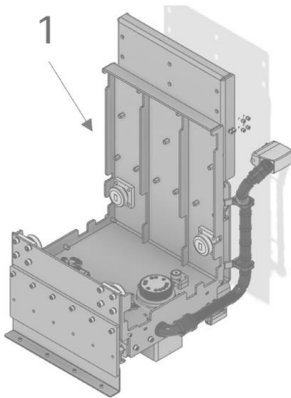
- The X Universal Carriage (XUC) allows for swapping between different future tool attachments on the X-axis.
- The main feature is to hold the printhead but other attachments such as a robotic arm or automating pouring of concrete will be available in the future.
- The universal carriage comes with a special blue stand/trolley to aid the exchange of tool attachments and move easily around site. The E-box should be placed in the lower section of the trolley while the sled is placed on the top horizontally.
- XUC has three main components:

1. **Sled:** Section that slides inside the X-axis.
2. **E-box:** Top part hosting electronics.
3. **Tool attachment:** For future features.

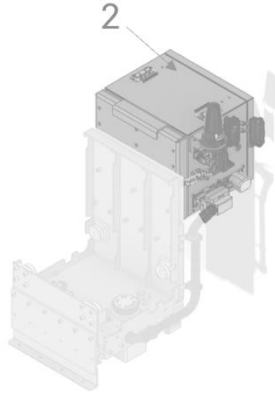
- The image below shows how each component is placed in the trolley.
- It is important to be familiarized with the parts of the universal carriage, please review the components below:



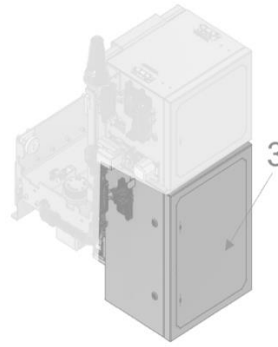
1.XUC Sled



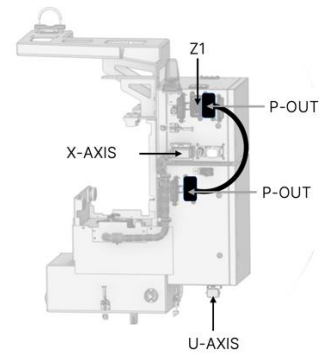
2.XUC E-box



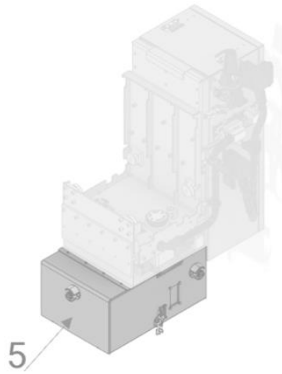
3. XUC Toolbox



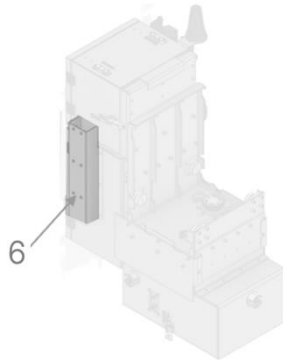
4. XUC connections



5.XUC Tool attachment

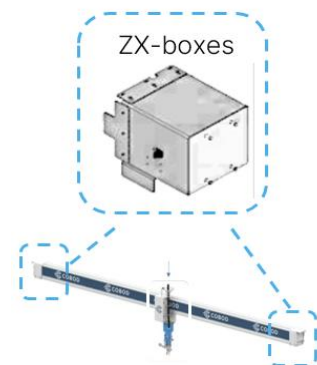


6. XUC Hose mount



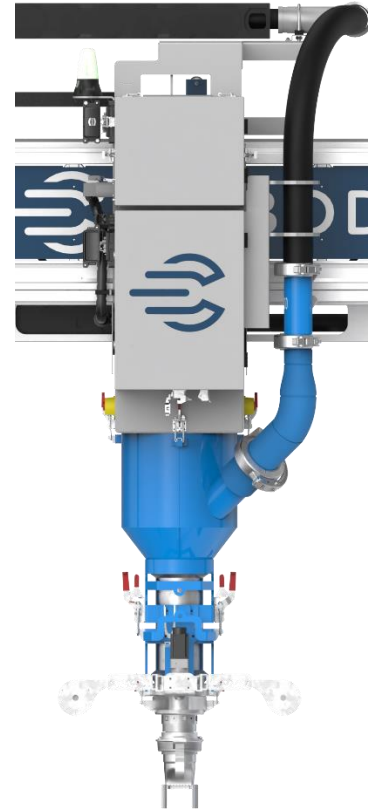
ZX1 and ZX2 boxes

On each end of an assembled X-axis, a ZX hollow box is placed on top of the Z carriages.



Printhead

The printhead has one input (male) plug, which is for the female end of the “Z1 – XUC” cable.



5.3 STATIC & MOVING CABLES



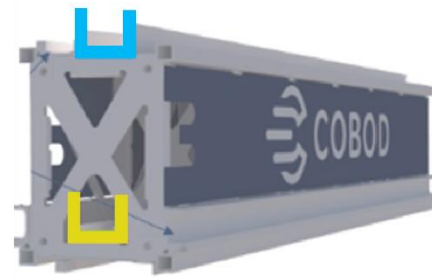
The diagram above shows the approximate location of the cables that run throughout the printer and connect everything starting from the Operational Stand.

The OS and carriages described in the previous chapter are all connected to each other in a specific sequence and connecting the chain in the right order is vital for correct machine functionality.

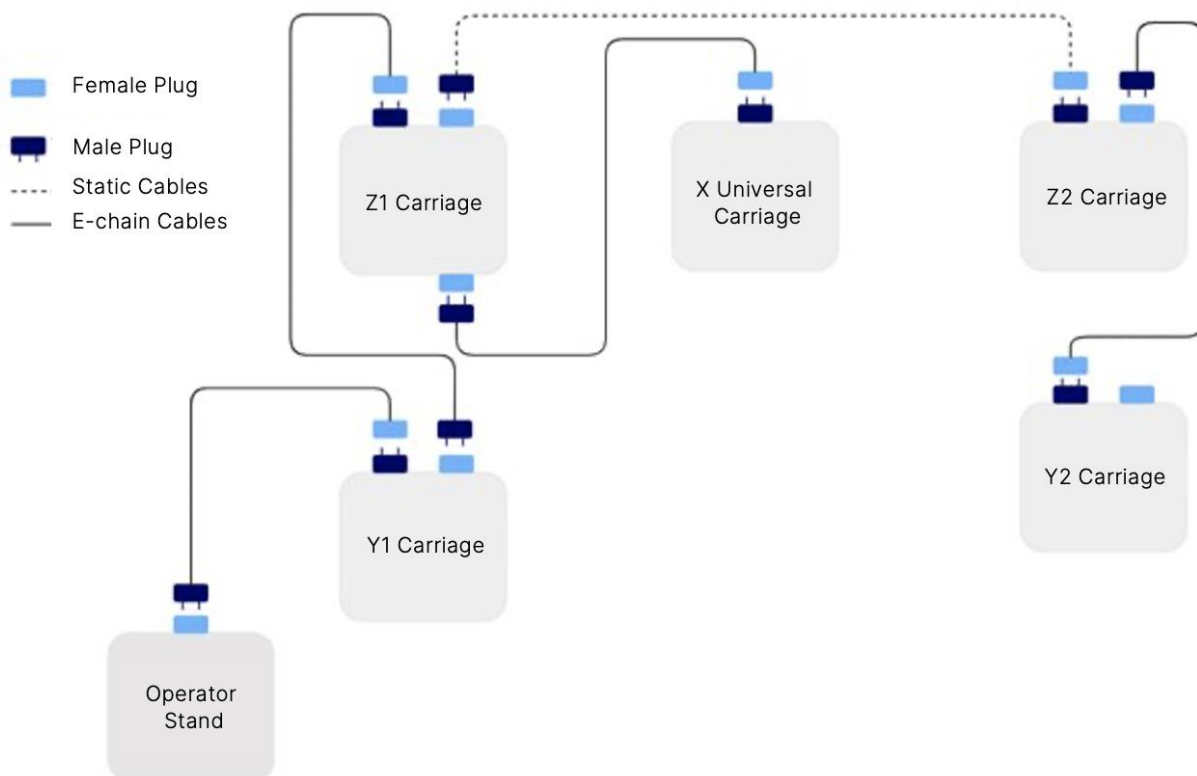
All cables required to run the printer fall into one of two categories: static cables without e-chain and moving cables inside an e-chain.

Static cables are used to connect the Z1 and Z2 carriages together. Static cables are run in the cable tray inside of the truss and the moving cables run in cable trays on top of the truss.

TRAYS LOCATION



5.4 BOD3 WIRING DIAGRAM



5.5 E-STOPS LOCATION

The BOD3 3D printer has a series of emergency stops (E-stops) located in different points of the machine in order to be easily accessible in case of need. Such locations are physical and digital.

The SoftNA display will indicate an E-stop map with the positions and status (engaged/not engaged). The image below shows all E-stops engaged. The map also shows additional safety components that would stop the machine in case of emergency but are not E-stops. For more detail, please review the section *Safety Features*.

Locations are:

- 1x - Operator's remote control
- 1x - Operational Stand
- 3x - Y1 carriage
- 3x - XUC carriage (near the printhead)
- 4x - Y2 carriage



5.6 SAFETY CONSIDERATIONS: ELECTRICAL

- Always wear full PPE when handling the machine.
- Avoid cables in wet areas and prevent tripping hazards with the correct use of protective cable covers.
- In extreme weather conditions, be cautious when handling electronic components that may become hot during operation and allow sufficient time for them to cool down before touching or inspecting.
- Follow local grounding regulations and procedures to prevent static electricity discharge, which can damage sensitive electronic components.
- Regularly inspect cables, connectors, and other electrical components for signs of wear, damage, or overheating, and replace any faulty or damaged parts promptly.
- Do not attempt to modify this equipment or create accessories not recommended for use with this tool. Any such alteration or modification is misused and could result in a hazardous condition leading to possible serious personal injury.



6.SOFTWARE COMPONENTS

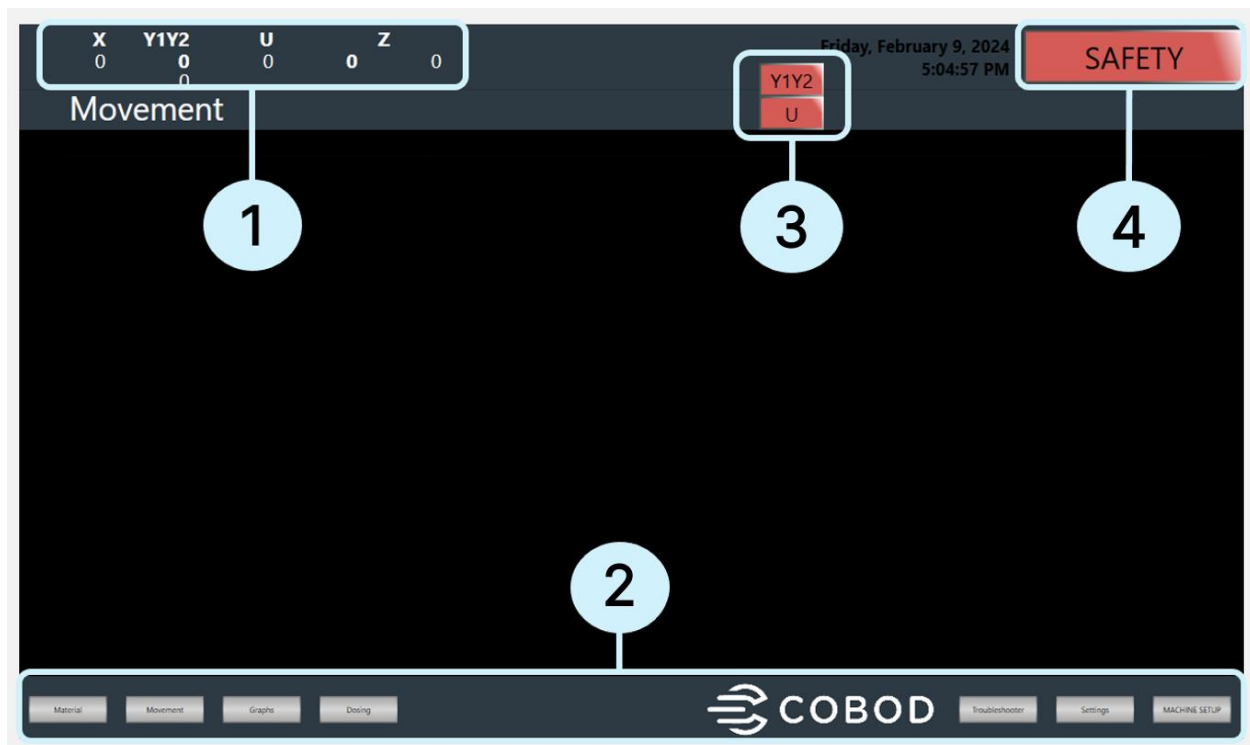
Definition

The BOD3 3D construction printer operates with two different interfaces; Soft-NA and Duet. The following section displays the most relevant tabs per program.

6.1 SOFT-NA

The BOD3 3D construction printer is controlled via the Soft-NA Software and Duet Web interface (DWC). The SoftNA is the HMI software which is used for start-up and to control the motors directly, calibrate the machine and define the print area. The interface is available via the onboard industrial PC (IPC) which is mounted on the Operational Stand. The software starts automatically when the printer is turned on, otherwise it can also be accessed remotely through a remote desktop.

6.1.1 SOFT-NA: HOME PAGE



1.MACHINE POSITIONS: Shows the current position of the U-motor and each carriage.

2.NAVIGATION BUTTONS TAB:

- **Movement tab:** includes switching between PLC/Duet mode, moving the printer manually and E-stop overview.
- **Material tab:** material related settings, incl. setting hopper level.
- **Troubleshooter:** opens the troubleshooter screen.
- **Dosing:** Dosing system calibration and setup.
- **Graphs:** data traces in graph format.
- **Settings:** set SoftNA speeds, pump type and visual settings.

- **Machine Setup:** homing and alignment.

3.Y1 AND Y2 INDICATORS: Shows whether Y1 and Y2 are misaligned after mastering (will turn red).

4.SAFETY: Shows if any safety features is engaged (will turn orange, if they are not – e.g., if Safety Override is in use).

6.1.2 SOFT-NA: MOVEMENT TAB



1.ENABLE DRIVES: The function of this button is to enable/disable the drives. This needs to be active for the machine to move.

2.PLC MODE / DUET MODE: Use this function to switch between the two system controls for the machine's physical movement. In "Duet mode" the machine can only be moved via the Duet Web Interface and in "PLC mode" the printer can only be moved via the HMI.

3.RED / GREEN BUTTONS: This row of buttons gives you a visual indication of which motors are engaged in Duet mode. The image above shows (in #2) a system engaged both in PLC and in a state of Emergency Stop which automatically disables the functionality in SoftNA hence the red interface.

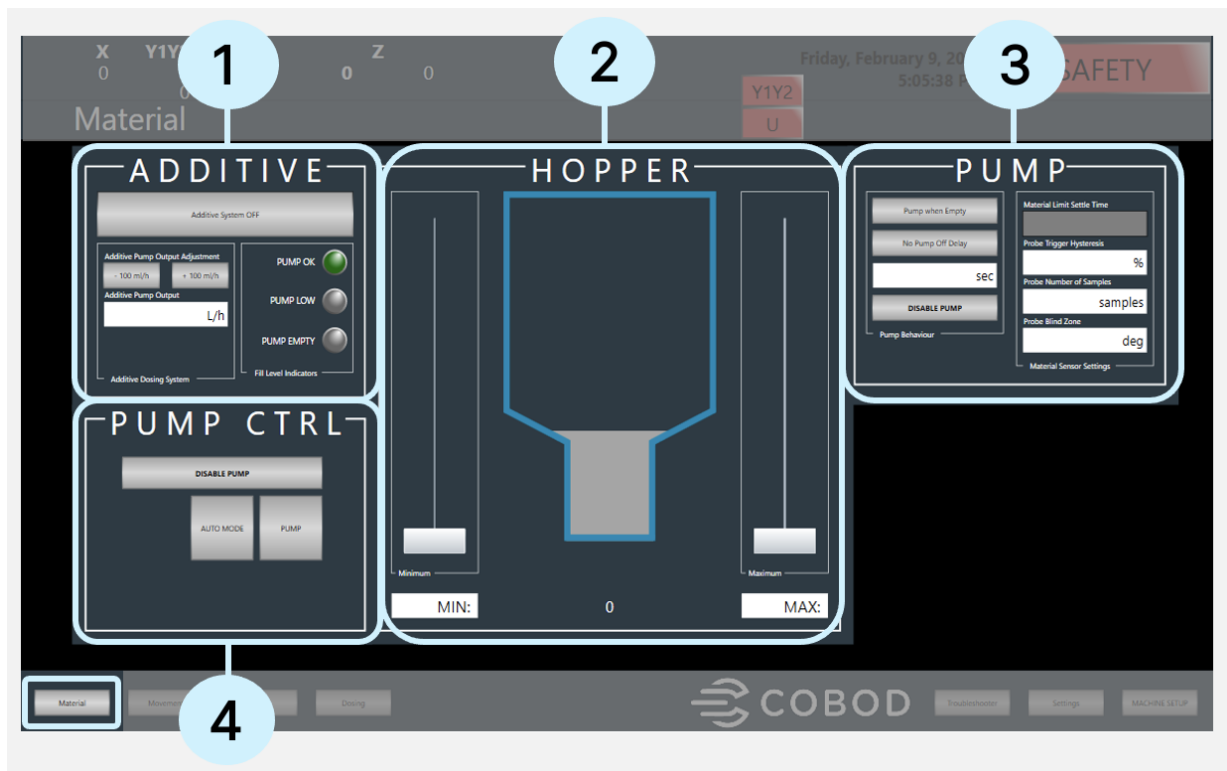
4.X, Y, Z, U, E: These are the manual movement buttons. When the printer is in "PLC mode" these buttons are used for manual movements of the printer. Clicking the label for an axis will bring you to the quick speed setting for a given axis.

5.E-STOPS: This section shows an overview of the yellow E-stop buttons in the printer. When an E-stop is pushed this overview indicates where the activated E-stop is located. Additionally, other safety mechanisms are shown, these are not specifically E-stop buttons but engage the machine the same way if triggered.

Below are some scenarios that could trigger an E-stop:

- When an E-stop button is pushed.
- Bumper impact with something.
- Inductive rail sensors when it no longer senses a rail.
- Printhead collision clickers
- Z-limit switches

6.1.3 SOFT-NA: MATERIAL TAB



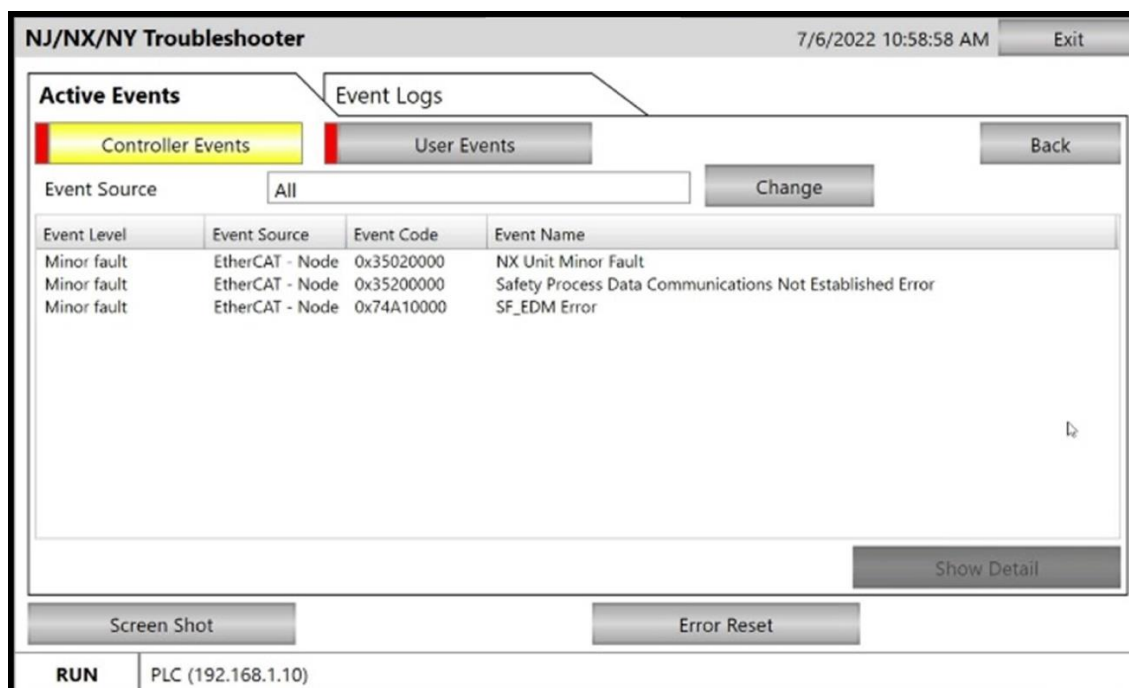
1.ADDITIVE PUMP: This additive pump is exclusive to the first admixture. For a complete breakdown in all pumps use the design page.

2.HOPPER LEVEL: This image shows the material hopper, you can adjust the material level with the two sliders in this section. The one on the left adjusts the minimum level of material, i.e., when the concrete pump should start pumping material. The slider on the right controls the maximum level in the hopper, i.e., when the concrete pump should stop pumping material.

3.CONCRETE PUMP: This section allows to activate and deactivate remote pumping, set a delay time for the pump to stop and ignore the level sensor when moving the printer in travel moves.

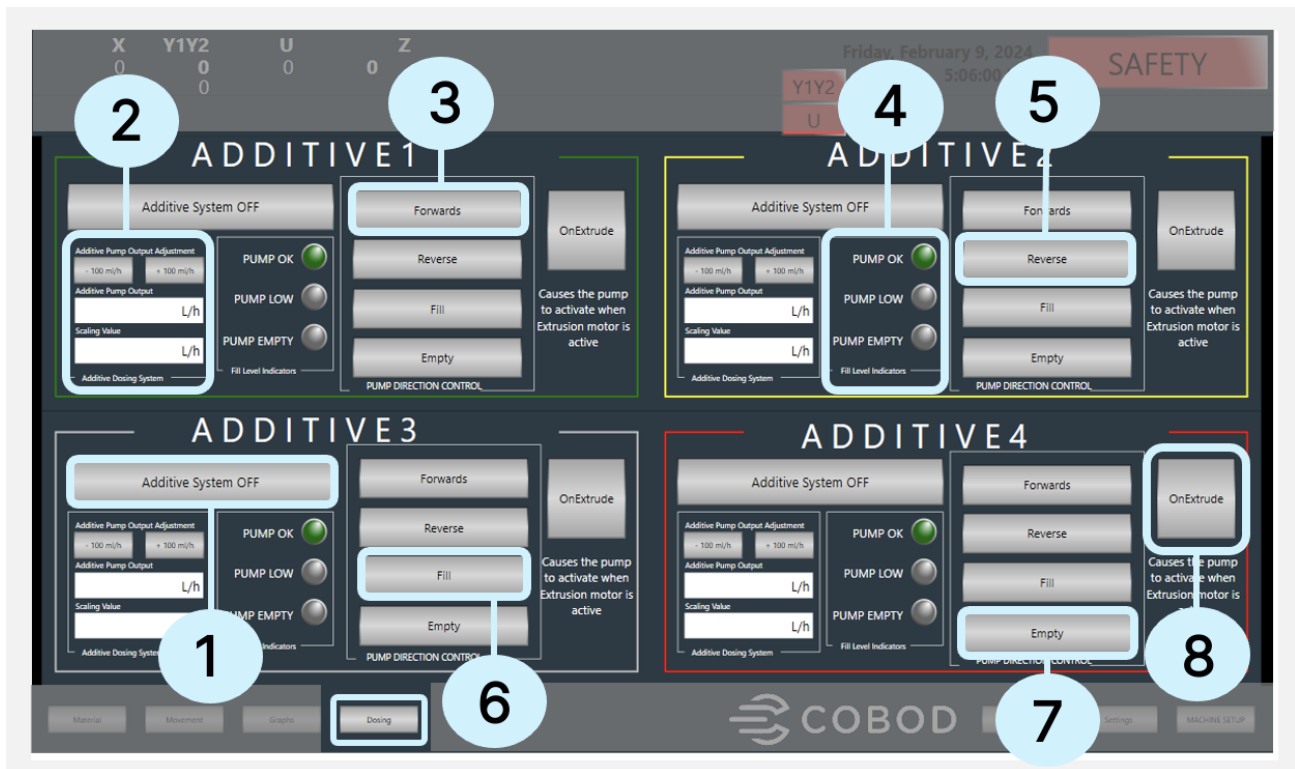
4.PUMP CTRL: These are the concrete pump controls. Here, you can turn the pump signal on and off, you can turn on automatic mode “auto mode” (where the concrete pump will use the signal from the material hopper level sensor to know when to pump). There is also a “manual pump” button that will turn on the pump when pressed.

6.1.4 SOFT-NA: TROUBLESHOOTER (POP UP)



The Troubleshooter in SoftNA allows you to directly monitor and release the NJ/NX/NY Controller errors and events as well as the user-defined errors and events. A more descriptive section describing each node can be found further down in this document in the section *Nodes*.

6.1.5 SOFT-NA: DOSING



1.ADDITIVE SYSTEM OFF: This button is a conditional for everything else to work. Enables the additive system signal to be sent from the printer and must be activated before the dosing system can begin normal operation.

2.ADDITIVE PUMP OUTPUT ADJUSTMENT: Speed settings allow for both precise and rapid adjustment of additive flow rate at any point during printing using either the manual input or using scaling value adjustment buttons. Scaling value is the maximum liters per hour that the pump can pump, should not be changed unless the viscosity of the liquid being pumped is very far from water. Only the output should be changed by operators during normal operation.

3.FORWARD: This sets the dosing system to pump forward on the pump signal of the printer, this is also conditional and must be activated before the dosing system begins normal operations.

4.PUMP OK, PUMP LOW, PUMP EMPTY: The following actions are required per scenario:

PUMP OK: No action required.

PUMP LOW: Operator should prepare a specific time to replace additive canister.

PUMP EMPTY: Operator should change additive canister immediately.

5.REVERSE: This sets the dosing pump to reverse pumping.

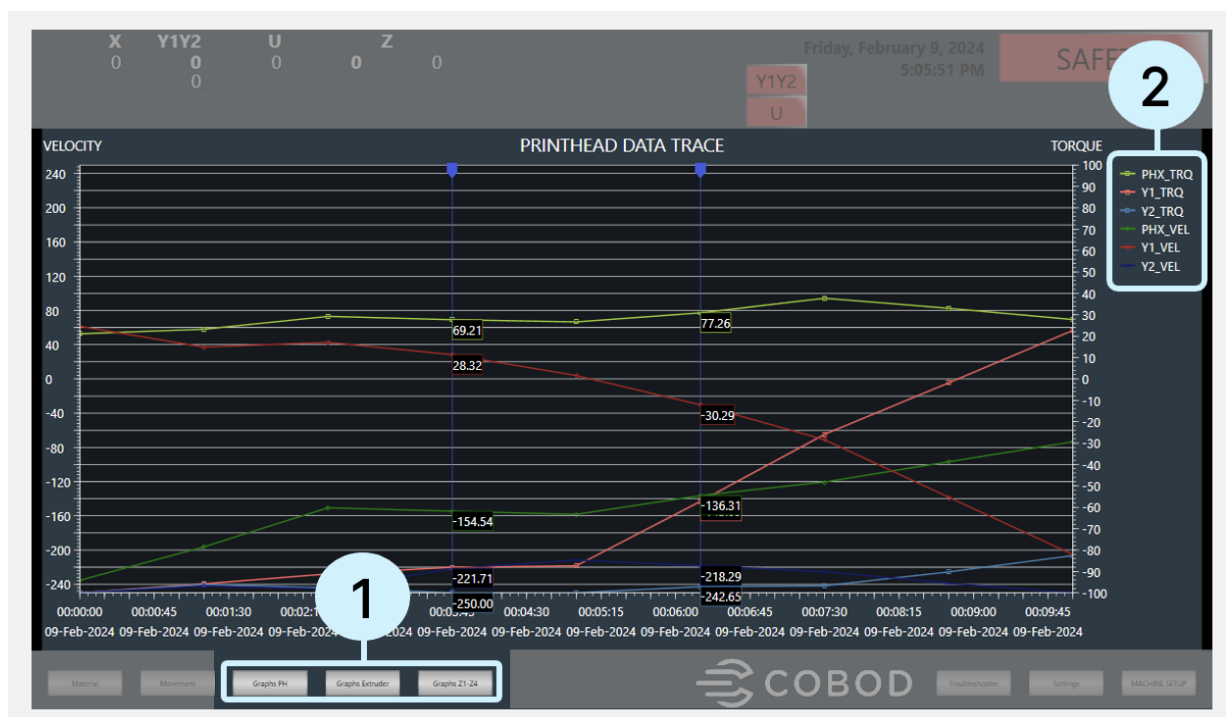
6.FILL: This sets the dosing system to constantly pump forward, a useful feature upon initial setup and calibration of the dosing system.

7.EMPTY: This sets the dosing system to constantly pump reverse, a useful feature when emptying the dosing system for cleaning or maintenance.

8.ON EXTRUDE: This enables the dosing system to only pump forward when the extruder axis is moving. This is a recommended feature as travel moves and other situations could lead to overdosing of material entering the printhead.

Each of these buttons holds all the same functions for each of the 4 dosing systems (if using more than one).

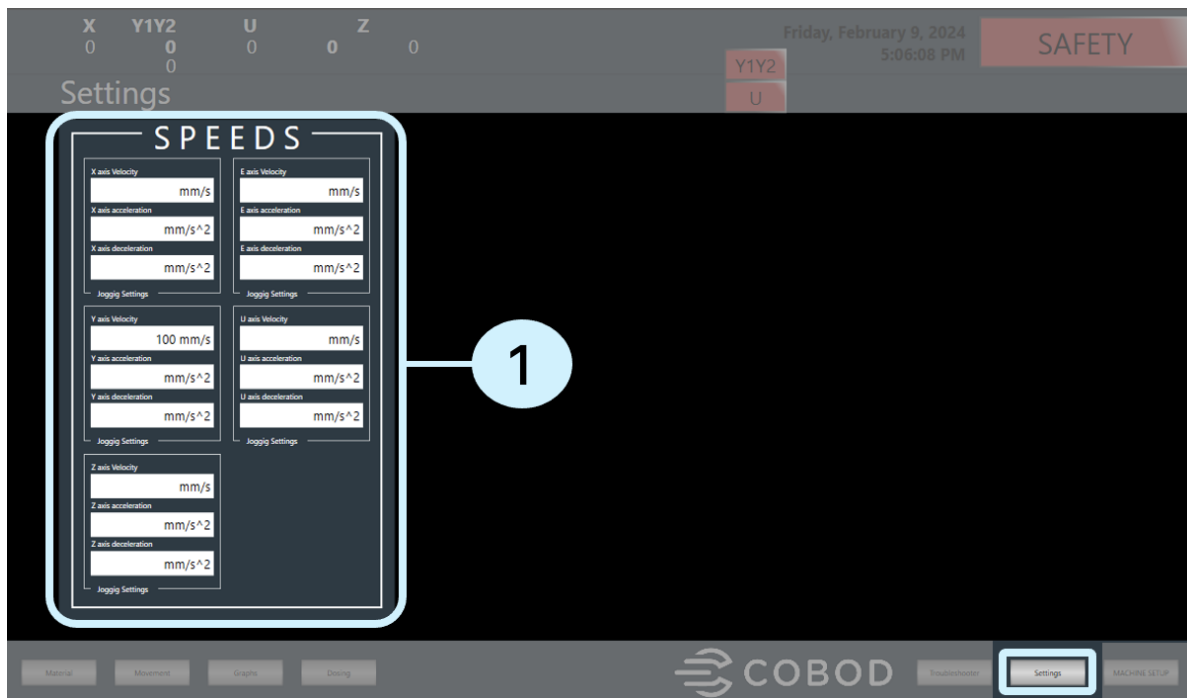
6.1.6 SOFT-NA: GRAPHS



This page allows you to monitor data from all the servo drives and monitor your machine's performance.

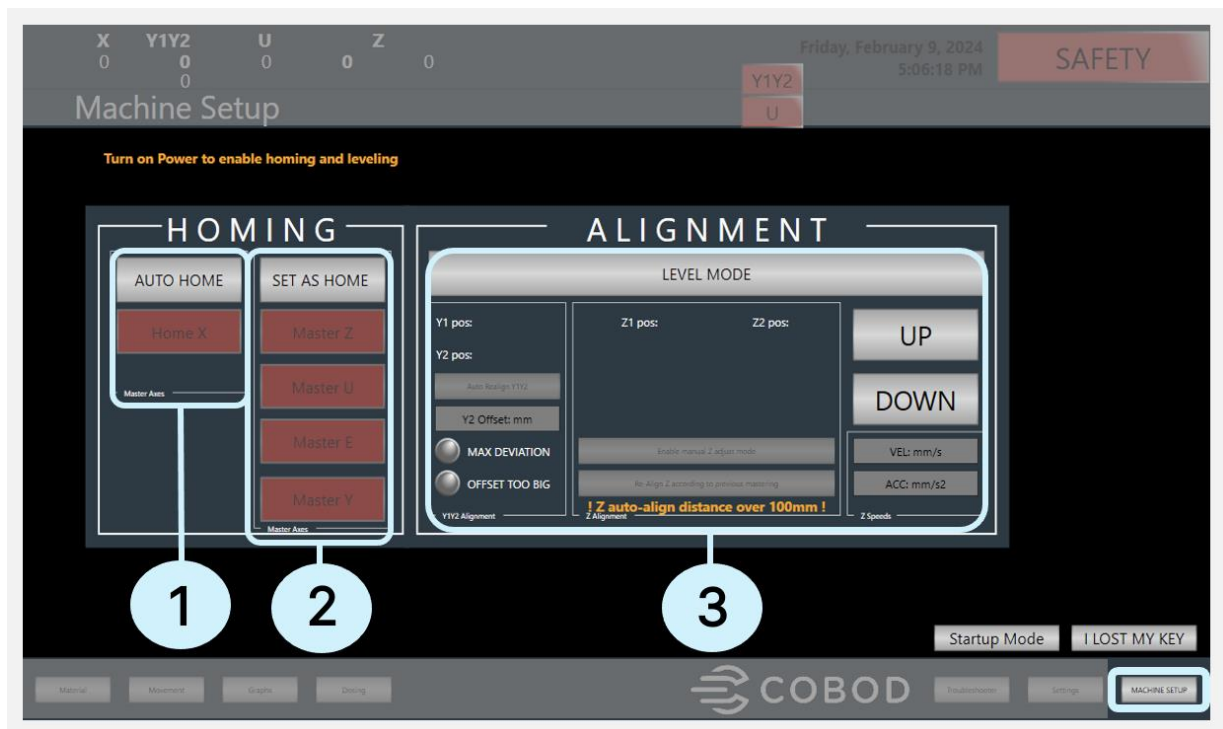
1. These buttons give you access to view different combinations of data.
2. Subject of what the different colored graphs apply to.

6.1.7 SOFT-NA: SETTINGS



SPEEDS: These are the settings for the speed that the printer will move at when doing manual movement in “PLC mode”. For every axis you can adjust top speed, acceleration, and deceleration. Standard maximum speeds for X and Y are 250 mm/s while for Z is 50 mm/s.

6.1.8 SOFT-NA: MACHINE SET UP



1.AUTO HOME This button will activate for homing the X-axis automatically.

 **Important:** Pushing this button will move the printer, make sure the print area is safe and that nothing is in the way of the printhead.

Ensure that the XUC homing clicker is installed as well as the X truss homing trigger bracket to ensure proper functionality.

2.SET AS HOME button will activate the options below:

- a. Master Z, moving the Z-axis to the position which will set the zero height in the Z-direction i.e., right above your slab or print area.
- b. Master U, which will zero the U-axis, this is done with the nozzle aligned along the back of the hopper.
- c. Master E, which will zero the extruder axis. This needs to be done with the mixing arm of the extrusion screw right below the material hopper level sensor. This is to better process the signal coming from the sensor – if not done correctly, the automatic pump control will not work properly.
- d. Master Y, which will zero the Y axis. Prior to mastering the Y-axis it is essential to follow the proper alignment techniques to ensure perpendicularity between the X and Y axis, these can be found in the assembly section of this guide. After this, simply move the printer to the closest possible Y position to the printer's MCS origin and press "Master Y".

3.ALIGNMENT: Here, you can set up a Y2 offset to make sure that the X-axis is perfectly perpendicular to the Y-axis. You can also level all the connected Z-carriages; choose any of the carriages you have connected and move them separately or simultaneously.

6.2 DUET

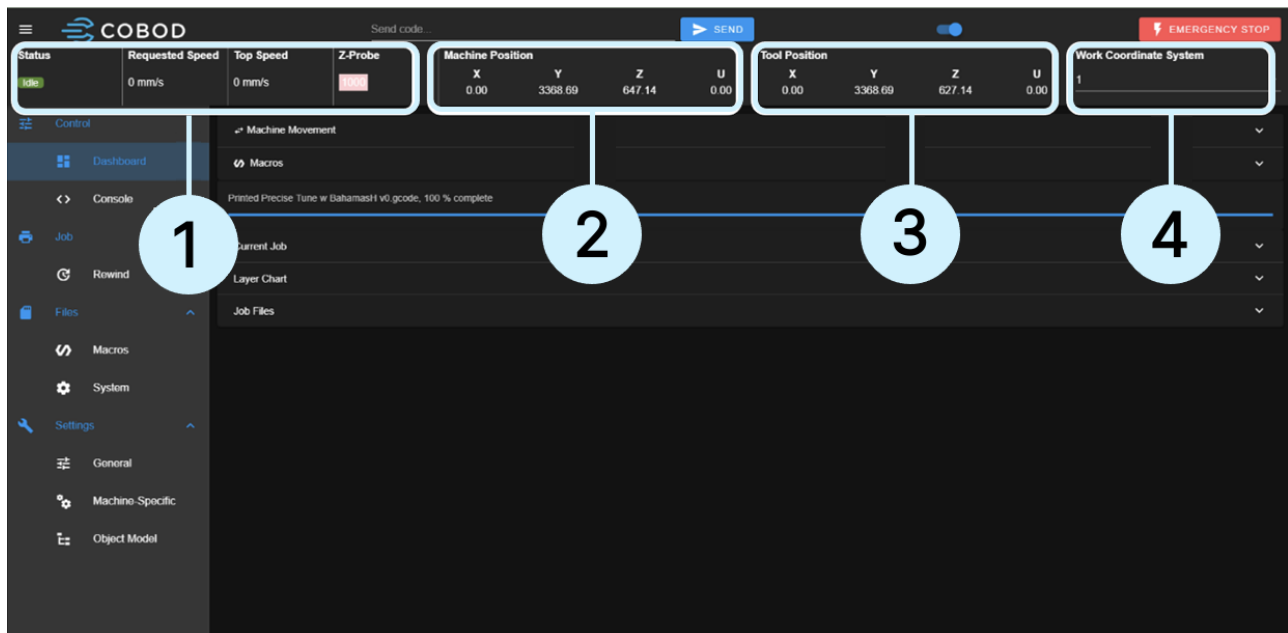
Definition

Duet is a web interface program (DWC) that allows the printer operator (PO) to control the printer from his/her desk through the laptop or walking next to the nozzle with a tablet. The DUET controller is a combination of hardware and software that reads G-code and sends the information to the OMRON PLC system of the printer. From the DUET interface you control the printer during most of your daily operation. To connect to the interface, you need to be connected to the printer either via wi-fi or ethernet and type the following IP address in your preferred web browser:

- 192.168.1.2

Before the user can control the machine via DWC, communication between motors and DWC needs to be established by "Gearing motors in" via Soft-NA. This is done via "Movement" section in Soft-NA, by clicking "Duet mode" button (Figure 6, A). With motors geared in, connect your device to the network the printer is on, either via Wi-Fi or via Ethernet cable directly to the main E-Box, "Client Socket".

6.2.1 DUET: HOME PAGE



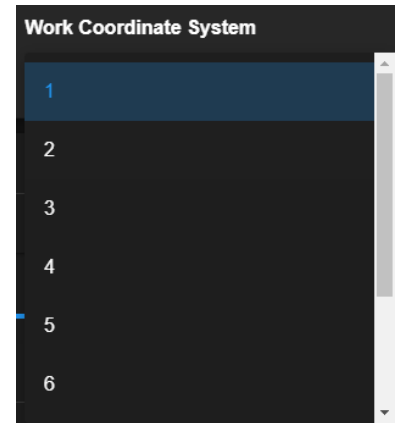
This is the front page of the Duet interface. In the top row you will find the following:

1. Status of the printer including at what speed it is currently moving and the Z-probe status.
2. Machine position shows the absolute position of the printhead as the PLC sees it.
3. Tool position shows the coordinates of the printhead in your chosen WCS.
4. Drop-down menu where you choose which WCS you want to work in.

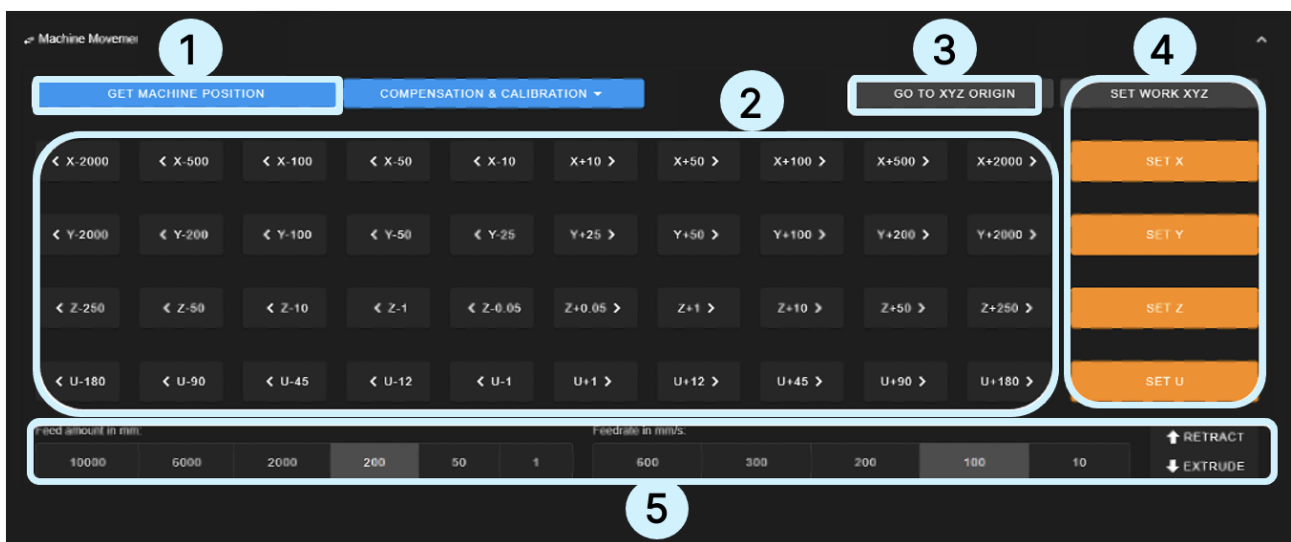
Next you can navigate the left column of tabs and you will find:

- **Dashboard**
- **Console:** Where you can see error codes and/or send commands.
- **Rewind:** Gives access to the rewind function.
- **Macro files:** Manage macro files.
- **System files:** View the printer's system files.
- **General settings**
- **Machine specific settings**
- In the center of the dashboard tab you can access:
 - **Machine movement:** Manual movement of the machine.
 - **Macros:** Activate macros.
 - **Current job:** Adjust settings while printing.
 - **Layer chart:** View the layer time from the previous layers.
 - **Job files:** View the job files stored on the DUET.

- **WCS** (Work coordinate system): This is the menu that lets you choose which WCS you want to work in.



6.2.2 DUET: MOVEMENT



In this movement drop-down menu, you can control multiple things regarding movement and position.

1.GET MACHINE POSITION: This button will pull the actual position of all motors and will import it into DUET. This button is usually used after moving the printer through the HMI.

2.MACHINE MOVEMENT: The array of directional buttons inside “Machine Movement” section allows for a single machine movement at the time, in either positive or negative direction. The numeric value of each button can be changed by using the right mouse button on it.

3.GO TO XYZ ORIGIN: Pressing this button will initiate movement of the machine to the Origo Position [X=0, Y=0, Z=0].

⚠ Important! Be cautious of any obstacles, as machine will take the shortest path to reach the Origo and the only way to cancel it is using Emergency Stop.

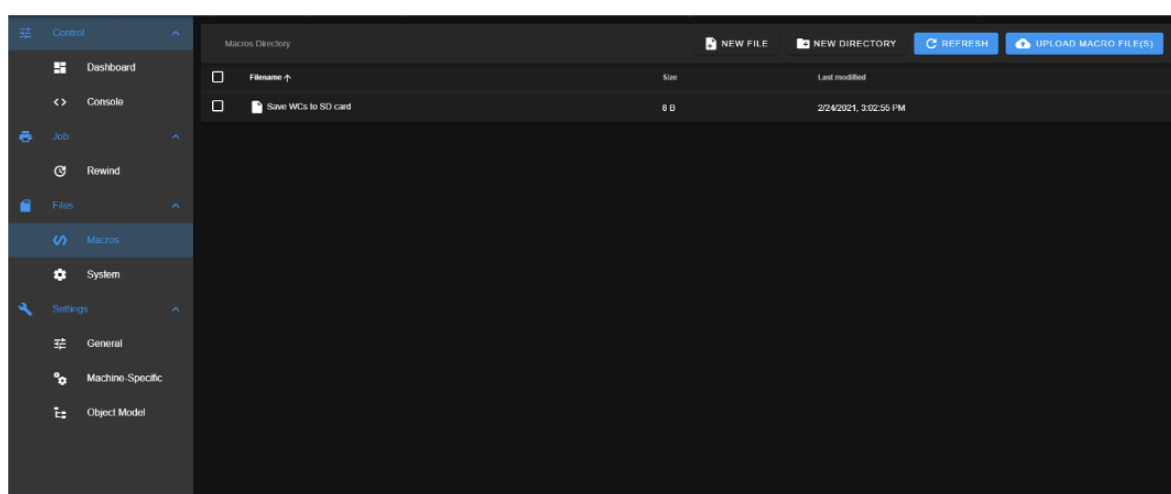
4.SET WORK XYZ: This section is used to position prints inside print area by setting current machine position as a new 0 value inside selected WCS. The top button will allow you to set all axes at once and the orange buttons will allow you to set them individually. If using SET WORK XYZ, make sure that U is in a zero position or that it is manually zeroed afterwards.

5.FEED AMOUNT: This is the manual extrude/retract interface. Use it to move extruder and discard varying amounts of material by setting “Feed Amount” (Volume), “Feed Rate” (Speed of Rotation) and clicking “Extrude”.

6.2.3 DUET: MACROS

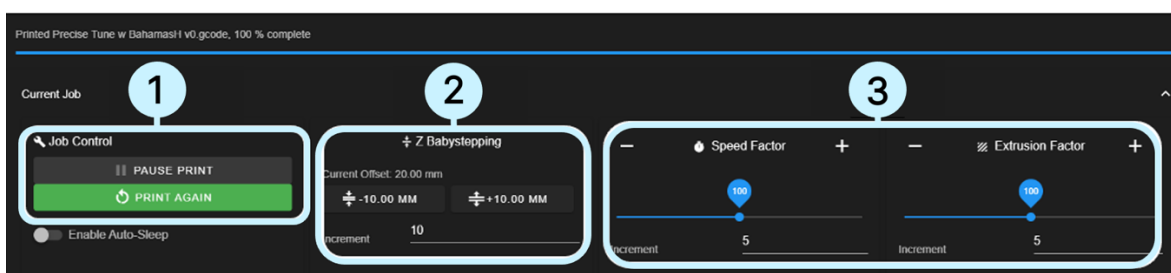


In the dropdown menu called “macros” you will find the available macros installed on your machine. A macro is a file that contains code that, when activated, makes firmware changes or performs a task in the printer.



In this tab you can access all the macro files that are installed. This is also where you add more macros.

6.2.4 DUET: CURRENT JOB



While running a G-code, relevant information about how the print is progressing and parameters allowing you to adjust the print will be shown under Current Job.

1. PAUSE PRINT: These buttons let you pause printing, continue printing, or cancel the current print.

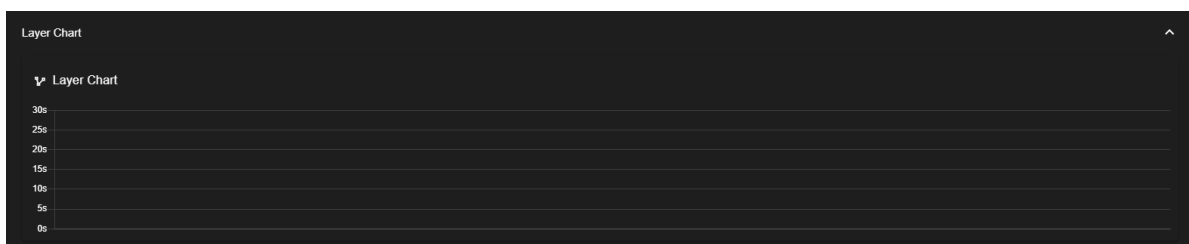
2. Z BABYSTEPPING: It allows you to adjust the Z-height while printing by offsetting your WCS either down or up. It is especially useful during the first couple of layers on uneven ground.

⚠ Important! Remember to cancel the baby stepping function once you are done with the correction, otherwise it will continue to run automatically.

3. SPEED FACTOR / EXTRUSION FACTOR: These are the sliders for controlling the speed of the printer and the extrusion factor. Both are usually adjusted continuously during a printing operation and expressed in %. These are the two most **crucial** settings to get right while printing. It is always the print operators' task to make sure the print speed is adapted to how the material is behaving.

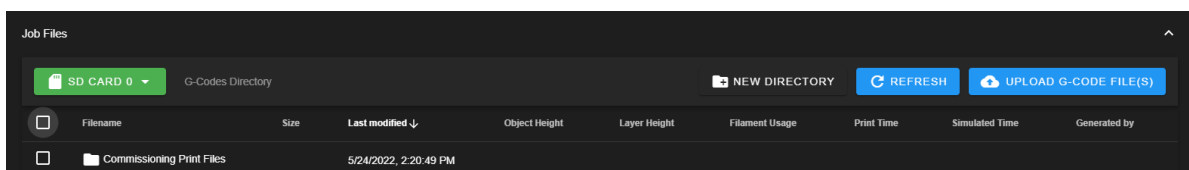
As a standard the speed factor will be set as 100% for a speed of 100 mm/s and operators can then adjust according to project specifications. Extrusion factor would follow the same pattern.

6.2.5 DUET: LAYER CHART TAB



Another important piece of data for the print operator is the layer time. In the “layer chart” drop-down menu this is displayed in a graph that shows the time of the last 50 layers.

6.2.6 DUET: JOB FILES



	Filename	Size	Last modified ↓	Object Height	Layer Height	Filament Usage	Print Time	Simulated Time	Generated by
☐	Commissioning Print Files		5/24/2022, 2:20:49 PM						

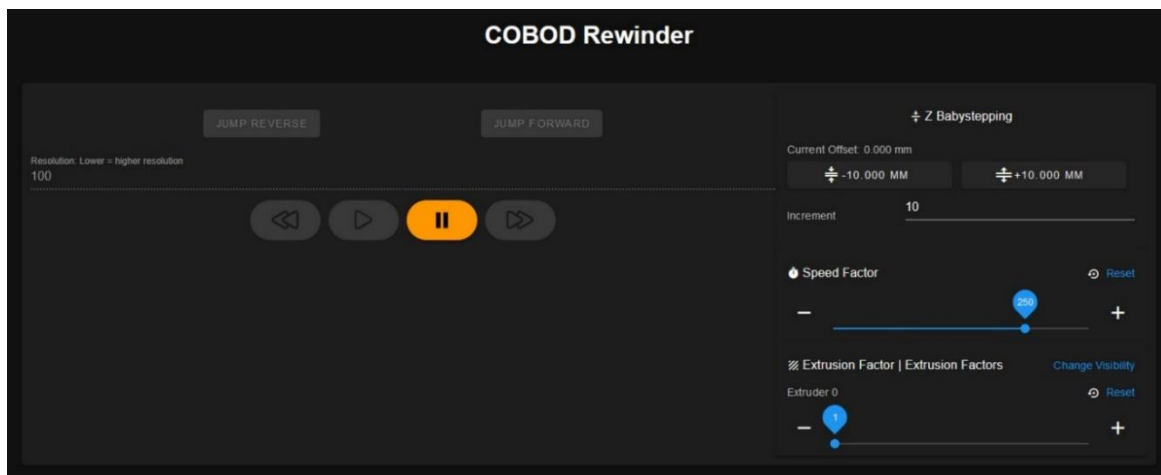
In the job files drop-down menu, all print files that have been uploaded are displayed. From here you can choose whichever file you need to print and upload new files by using the “upload G-code files” button.

6.2.7 DUET: REWIND

This plugin gives you control over rewinding and fast-forwarding a G-code file that is currently being printed. Main application is to quickly fix big prints without having to re-slice the geometry (in case of issues with material/extrusion).

Due to Duet plugin environment limitations, the **Rewind plugin needs to be manually activated** so it could be used right away when needed. To activate it, once the printer is turned on, the operator must click on the “Rewind” tab via the Duet Web Interface. If you see the Rewind interface, it is activated.

After activation, any G-code ran by the printer will have to be downloaded to the buffer of web browser used for the code manipulation via Rewind to work. If the plugin was activated, the download will start automatically after the print is started and that will be indicated by a progress bar found in bottom left corner. Keep in mind that if the browser window is closed or re-freshed, G-code needs to be downloaded again.

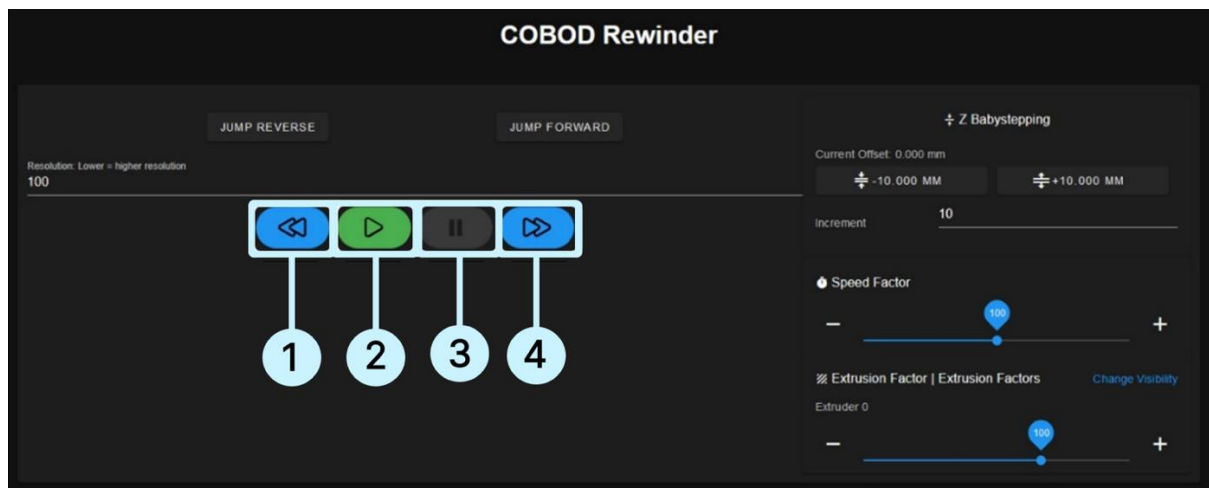


COBOD Rewind Plugin Interface while in

Pause the current print to Rewind

To start using Rewind, the print must be paused. That can be done either via Dashboard or Rewind tabs. It will have a different effect towards Speed and Extrusion values, depending on which Pause button the machine operator uses:

- If paused via Rewind tab, print speed will be reduced to 50 mm/s and extrusion to 1 %
- If paused via Dashboard, the values will be kept the same as before pausing.



Rewind controls:

1. MicroStep reverse
2. Resume the print from here
3. Pause (either the print or the MicroStepping)
4. MicroStep forward

There are two sections here: Jumping and Continuous Micro Reversing/Forwarding. For Jumping, you can choose how many lines of G-code to jump at the time and click either "Jump Reverse" or "Jump Forward". Useful while looking for a place where print got interrupted by using bigger jumps to start with and small jumps to pinpoint the exact location. Micro Reversing/Forwarding is a continuous movement either backwards or forwards along the G-code. Executed by clicking either << or >> icons. Micromovements reads only every second line of G-code, hence do not be surprised if the printer is performing some diagonal movement along X,Y and Z simultaneously.

Once going either direction, movement can be stopped with the "Stop" button located in between "Rewind" and "Forward" buttons. Speed can be controlled via the "Speed" slider present on the right-hand side. You can also extrude while doing this, just do not do it while going backwards and using flaps - you'll scrape the printed walls.

Quick guide

- Pause print via Dashboard or Rewind Tab.
- Z baby step up:
- If using flaps, Z baby step should be equal to the length of the Flaps + 5mm.
- In case no flaps are used, Z baby step should be set to a height equal to two times the layer height in which the print was sliced. I.e.: layer height of print was 20mm, then baby step Z up by 40mm.
- Use Jumping and/or continuous stepping to find a place where you want to print from.
- Z baby step back down to the height the print was paused at.
- INCREASE EXTRUSION! (If paused via Rewind tab, extrusion is automatically reduced to 1, to not extrude while rewinding).
- Depending on how long it took to find the location to resume from, you might consider extruding a little amount of material to make sure there is a good flow and material did not cure too much around the extrusion screw.

 **Important!** Always resume the print from the rewind tab! Green “Play” button in the middle. Otherwise, if resumed via Dashboard it will resume at the place in which the operator originally paused.

6.2.8 DUET: Work Coordinate Systems

Once setting the origin of the 3D printer (upon installation), the MCS (Machine Coordinate System) is determined. Within the MCS it is possible to set up multiple – up to 9 – WCS’s (Work Coordinate Systems).

Example:

Prerequisite for the following is to have BOD3 set up including homing, printer powered on and having the machine operator PC connected to the Duet Web Interface.

Once Duet and motors are synchronized via Get Machine Position button, the Machine Position will be updated. This coordinate system refers to the minimum and the maximum physical positions and is defined by the configuration of your machine.

It is perfectly fine to only use MCS while learning how to operate BOD3 machines to focus on other aspects of printing first: machine control, file preparation, dry runs, etc. However, WCS is a very useful tool while aligning smaller prints in the print area or offsetting bigger ones to match drawings with physical printer position. WCS is a coordinate system inside MCS. The printer remembers such systems as precise offsets from main MCS, and the printer operator can switch between the machine and multiple work coordinate systems on the fly.

 **Important!** Once WCS are created/updated, the macro named Save WCS to SD Card needs to be executed to be saved. If not done, the new WCS will be lost once the printer is powered off or the Duet board is reset. Also, it is recommended having the “1” WCS identical to the MCS.

6.3 SAFETY CONSIDERATIONS: SOFTWARE

6.3.1 SAFETY OVERRIDE

 **Important!** Safety override is a feature which must be well understood by the machine operator. It should be performed with great caution and ONLY if necessary.

During normal printer operations, Safety Validation is responsible for making sure that everything in the system is functioning as it is supposed to, before allowing any movement of the machine.

However, using Safety Override disables the Safety Validation system. It will not fix any motor, hardware or cabling related issues. Functioning parts of the printer will still be allowed to move, while non-functioning ones will remain immobile! Allowing printer operations with the Safety Validation disabled can potentially damage the machine severely and cause serious injury to personnel on site.

Safety override can be used in various situations, some will be relatively safe for personnel and the printer, and some will endanger both – it is all down to the severity of the issue that demands using the override to move the printer. Either way, a safety override is only to be used

in emergency situations as the safety of the machine and personnel is going to be compromised.

Before using the safety override to move the printer it is important to have diagnosed the issue or at the very least have an idea of where the issue might be affecting the printer's operation. If for example one of the Z-carriages has an issue that stops it from moving, you should not try to move that axis as that will drastically misalign the printer and very likely damage the equipment. When using safety override everybody on site should always pay extra attention to the movement of all the axes.

Potential situations where the safety override can be used:

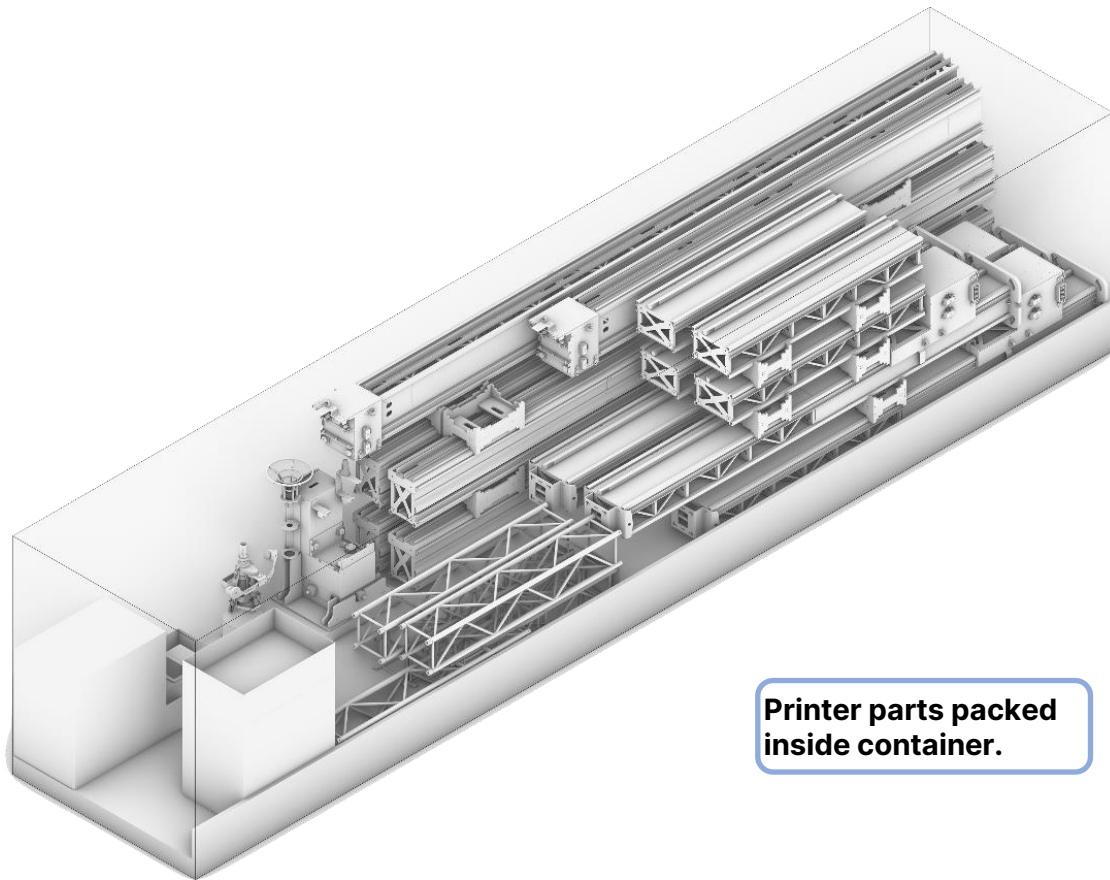
- If you have crashed the printhead into the ground, the printhead clickers will in certain situations be activated until you move the printhead. To be able to do this, a safety override will have to be used. Usually, the printhead moves up slightly (20 mm) when the clickers are activated.
- If you have top end stops installed on your machine, then you also must use safety override to lower the printer if they are triggered.
- If you are printing very high up and one of the e-stops on the Z-leg is triggered or even damaged by a worker not paying attention, then safety override can be used to lower the printer for cleaning.

Use:

1. Insert the Safety Key in the keyhole right under the IPC of the main E-box.
2. Ensure the machine is in PLC mode (SoftNA) and motors are engaged. Remember it should NOT be in DUET mode, since it might start moving.
3. Turn the key clockwise.
4. Soft-NA will indicate that the Safety Override is enabled by flashing the light above the X carriage green/red and beeping.

Access: Two sets of Safety override keys are included with the machine. It is recommended to have one copy bundled with the Control Panel Keys. **Never** leave the safety override key in the keyhole.

7. INSTALLATION, PACKING & STORAGE



Definition

The following section covers general information about the shipment of COBOD equipment as well as best business practices when planning to pack your printer inside a container or flatbed truck. If you are unsure how to pack specific items to prevent damage or need further assistance, please contact techsupport@cobod.com

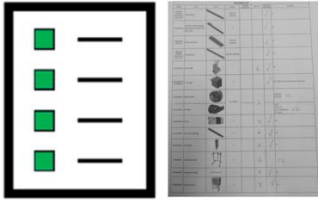
Responsibility

Printer shipping operations fall under the printer specialist (PO) scope of work but are a shared logistical coordination with the project/site manager.

Transportation

Printers are packed from the factory in 20 or 40 ft containers depending on the chosen configuration. Containers are then transported via vessels overseas or via truck inland to their destination.

The offloading of the printer from the container requires equipment specified in the *Site Readiness Checklist* document.



1. Inventory control

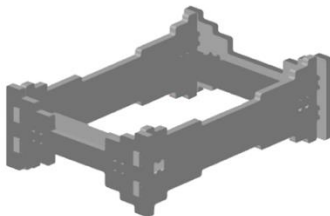
Keep organized inventory checklists when moving equipment from site to site. Watertight bags for checklists are highly recommended.



2. Loading parts

Correctly accommodating items inside a container or flat-bed truck should always be assessed to site specific conditions by the PO responsible.

Typically, accommodating items start by placing the larger and heavier parts inside the container first and accommodating additional items second.



3. Wooden stackers

Wooden stackers are a transportation and storage accessory for printer axes (X, Y and Z) and should not be disposed upon arrival.

They are meant to be placed between axes to prevent damage from friction but could also be placed directly to the ground or on top of pallets.

As a rule of thumb, one wood stacker per module distributes the load correctly.

Of all axes that use stackers, the X-axis requires more attention when resting due to the tooth rack sticking out more on the bottom section which **always** requires stackers before being placed.

Please note the wood stackers included in your original shipment are disposable and not for long term use, furthermore, wood stackers are not weatherproof and will decay over time if exposed to humid environments.

To keep printer elements in stable positions, it is important to replace stackers when physical damage is identified.

A digital file is available in COBOD Connect to locally produce more permanent stackers.





4. Custom stackers

The printer comes with custom made stackers to safely transport certain components such as the XUC carriage seen in the image to the right.

These stackers need to be kept in good shape away from direct contact with water to last longer and should be replaced when visible damage is identified.



5. Wooden pallets and frames

Pallets and frames are part of your packing equipment and require periodical maintenance.

A pallet lifter is recommended upon reception to ease of-loading and site handling operations.

Keeping accurate checklists per box will ease inventory control and customs handling.



6. Wooden block spacers

Use wooden block spacers between objects or gaps where an object could touch the walls of the container to prevent dent damage during transportation.



7. Electrical connections

Check all electrical cables and plugs are correctly closed or watertight. Leaving plugs exposed could damage the pins inside and/or expose components to humidity.



8. Equipment securement

Securing equipment for transportation (truck or container) with ratchet straps or tie-down straps is essential for safe transportation

Correct security stabilizes the loads, preventing accidents and equipment damage during movement.



9. Stacking

Never stack more than 3 trusses high on top of each other for stability purposes.



10. Rigging equipment

Due to the fast modularity of COBOD printers, rigging operations must be risk assessed and approved by site managers in consideration to their specific environment, local regulations, number of people involved, specific lifting equipment and operations plan.

11. Review

1. Perform an inspection of the equipment inside the container(s).
2. Take the opportunity to familiarize yourself with the names of the components.
3. Check that all parts have been received – refer to belonging shipping list.
4. Check for damaged parts in shipment.
5. Unload container(s) in coherence with your site plan, to ease the installation.

7.1 STORAGE RECOMMENDATIONS

Idle equipment

If the machine is intended to be non-operational for an extended period, it is highly recommended to disassemble and store inside a container performing routine inspections, at least, once every two weeks. If the machine is planned to be stored outside without any type of cover, increase the number of inspections, and secure all potential loose components.

Verify all caps from electrical components are correctly closed, remember to remove cables and admixtures and store them at room temperature. Drain all fluids (chemical tubes, MDS, concrete hoses etc...) to prevent damage from temperature fluctuation and close inlets in the hopper to avoid animal nesting.

Please note, rodents can chew different types of cables causing extensive damage, if an animal nest is found, remove and displace in accordance with local regulations and/or contact your local animal protection office for support in the disposal of animals with care.

General theft, humidity, rust and animal nesting is common and could lead to financial loss. Monitoring the stage of the equipment and preventing the above will extend the life of your machine.

Humidity

While the BOD3 system is designed to be outside, intense humidity can cause damage to some electronics if water is filtrated inside the carriages. To prevent this, monitor all moisture detecting silica bags or humidity monitoring cards inside the electronic boxes in the machine once a week or during intense humid conditions. If any of the silica bags is triggered or you see a change in color, **DO NOT POWER ON THE MACHINE** until fully examining the affected carriage and drying it out thoroughly. Be sure to also contact techsupport@cobod.com for any visual damage to electrical components so replacements can be ordered.

If the machine is stored outside, we recommend tarping the main electrical components during non-operational hours or monsoon season.

Please note the wooden stackers used for the original transportation of the printer are for temporary use only and are not waterproof, they can last longer if kept dry but are not intended for long term use. You will need to download the stackers file available in COBOD Connect and create your own with more resilient material for extended use.

Dirt

Dust, sand and other airborne debris can collect in the mechanical components of the BOD3 machine and cause unwanted wear and tear. If your equipment is installed near trees or in areas prone to windstorms or sandstorms the importance of covering stored equipment and keeping it generally clean will be higher. Follow COBOD's recommended maintenance practices to always keep your equipment in good conditions.

Extreme temperatures

The BOD3 machine is capable of operating in ideal conditions between 10°C and 35 °C. Printing past this range could be achieved but requires a set of additional precautions that are commonly applied to all heavy-duty equipment and traditional concrete for such environments.

Storing the equipment or not using it overnight under extreme conditions will require additional monitoring such as draining all systems, verifying all lids and caps are fully closed, humidity bag checks and storage of admixtures indoors or at room temperature away from direct sunlight. Further information is provided in the section *Extreme Weather Conditions* of this document.

Earthquakes

Items secured/bolted directly to the ground would have an increased risk of misalignment due to soil movement during an earthquake.

Remember to follow local regulations regarding industrial sized construction equipment, always prioritizing personnel safety.

After an earthquake, misalignment of the printer might occur with higher risk for broken bearings, be sure to verify all mechanical components and tolerances before resuming operations. After verification and while the machine is on, perform test moves and pay special attention to any unexpected noise that could indicate misalignment.

Storm and hurricane preparation

The BOD3 can withstand common weather but in the event of strong storms, hurricanes or tornados it must be treated as any other large-scale construction equipment and comply with all local safety regulations and time alert constraints.

A specific protocol for securing or dismounting the equipment must be created in advance by the site manager with site-specific considerations so it can be triggered in case of need. In any case, take extensive photos and videos of the equipment after the event and provide to techsupport@cobod.com for assistance in refurbishment.

8. INSTALLATION PROCEDURE

Before starting this chapter, please review the *Printer Components, Orientation, Movement, Mechanical and Electrical Components* sections of this SOP to familiarize yourself with the terminology.

Below is an overview of the installation procedure for the BOD3:

1. Team received L1 training.



2. Site readiness checklist (SRC) is complete.



3. Mechanical pre-assemblies are complete.



4. Install driving plates.



5. Install Y1 and Y2.



6. Safety considerations on Y carriages.



7. Install Z1 and Z2.



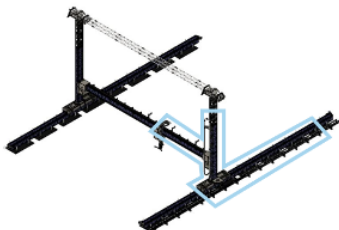
8. Install XUC, X-axis and print-head.



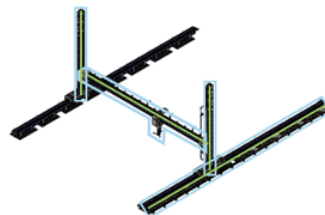
9. Install Z connection system and Dyneema ropes.



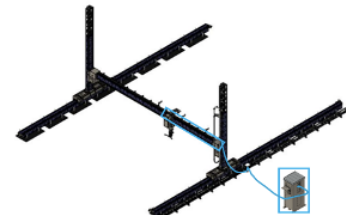
10. Install the AHMS and rest of components.



11. Electrical assembly.



12. Dosing system connections.



13. Printer homing, internet connections and cameras.



14. SAT completion.



8.1 LEVEL 1 TRAINING

The team who will operate both the printer and the material delivery system must complete the online L1 training and pass all the evaluations before L2 on-site installation starts. The certificates should be kept at hand in case the site is visited by any regulator.

This ensures that everyone is familiar with the concepts, parts of the equipment and operation procedures, which will contribute to the successful installation and future completion of projects.



8.2 SITE READINESS CHECKLIST

The SRC is a helpful list to make sure everything needed for the installation is ready and on-site before the process starts. It is required to prove all items are completed, including tools, lifting equipment, ground specifications, site requirements, water supply, power source, and others before scheduling L2 or providing the “Go” for a project.



8.3 MECHANICAL PRE-ASSEMBLIES

The BOD3 requires certain elements to be assembled before starting the sequence, such elements are related with the Z-Connection system, AHMS, mounting system and general modules/trusses connections.

Any item that can be advanced to reduce assembly time should be considered.



8.3.1 SPLITTING AND ASSEMBLING TRUSSES

Both X and Y trusses have 3 fishplates each – X has three small ones and Y has two small ones and one large called fishtail.

To split the trusses:

1. Remove all bolts from fishplates.
2. Loosen M16 bolts.
3. Remove all fishplates, if they are not removed prior to disassembly, they will be snapped or deformed. If fishplates are stuck, loosen the M16 bolts and wiggle the truss gently from side to side, while trying to pry the fishplates out with a screwdriver.
4. Undo the four M16 bolts connecting the trusses completely.
5. Place fishplates and bolts in a bag or another safe place to keep track of them.

To assemble the trusses:

1. Align the ends of the trusses to be assembled. Y-modules can lay directly on, for example, a pallet or another stable surface, while the X-axis modules must always be placed on the

provided stackers to protect the tooth racks which are mounted underneath. Once roughly aligned, place the M16 Bolts (with nuts and washers). Do not tighten fully!

2. Place the fishplates to align the trusses. Once placed correctly, tighten them. Lastly, fully tighten the main bolts (should be torqued to 240 Nm/176 ft lbf).
3. Use the Tooth rack calibration blocks to ensure that the tooth racks are aligned as expected. If not perfectly aligned, contact techsupport@cobod.com for further instructions. In some cases, the removal of safety elements is needed to perform a reduction or expansion in an axis. Beware of this and stop operations when performing such works to prevent any potential accident.

8.4 INSTALLATION OF DRIVING PLATES

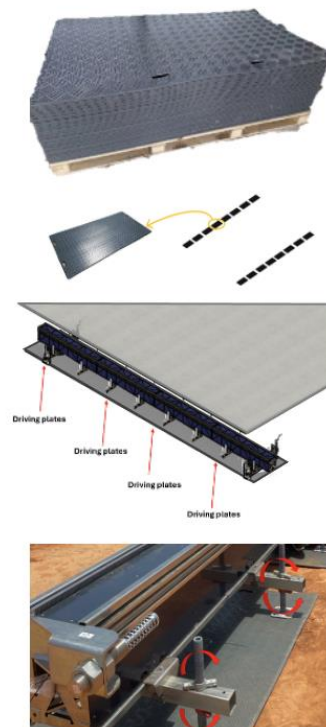
The driving plates ensure that the crossbeam and feet are standing on a flat surface, and its installation is as simple as placing each plate (one per module) and trying to align them with the print area if possible so it can keep even weight distribution.

The driving feet are only needed when the installation is happening in an uneven ground. When installing on a flat surface like a concrete slab, this step can be skipped.

The 3 alternatives for placing the Y axes are:

- Driving plates on uneven ground
- Y-axes on extended concrete slab
- Y-axes on parallel sidewalks

Keep in mind that the last 2 options require appropriate planning and precise measurements.



The steps for placing the driving plates are as follows:

1. Locate the required number of driving plates/crane pads (1 x driving plate OR 4 x crane pads per Y2 truss module).
2. Slide the driving plates/crane pads beneath the truss modules and align them to ensure that each of the crossbeam scaffolding feet will make full contact with the driving plates/crane pads.
3. Rotate the scaffolding feet nuts downwards accordingly to lower all of the scaffolding feet until they make full contact with the driving plates/crane pads.
4. Rotate the lower scaffolding foot nuts upwards so that they are in full contact with the underside of the crossbeam.
5. Rotate the upper scaffolding foot nuts so that they are in full contact with the upper side of the crossbeam.
6. Remove the stud and locking pin from the crossbeam and truss wheel jack assembly.
7. Remove the truss wheel jack assembly from the crossbeams.

8.5 INSTALLATION OF Y1 & Y2

To install Y1 and Y2, installers should prepare and calibrate the axes in segments of 4 modules each.

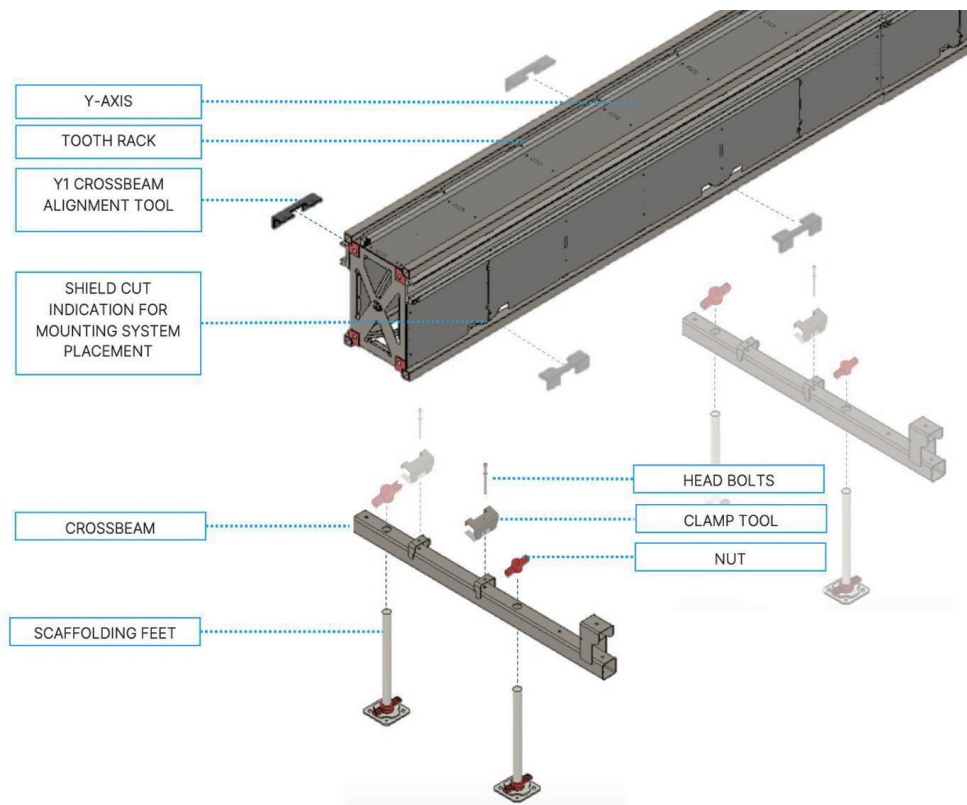
These segments are then located near their final intended area by using known measurements from the specific site layout. The multiline laser should be used to create a horizontal laser plane that we can later reference during the levelling process. After the 4 modules are prepared and in location.

1. Install the mounting system.
2. Connect all pending 4 modules segments together into the first final axis.
3. Fine tune the placement and repeat for the second axis.
4. Align the Y1 and Y2 between each other (perpendicularity) with the use of a multi-line laser and the distance laser.
5. Level them (height and verticality) with the use of a height leveling tripod.
6. Installing the Ys correctly is the most crucial part of the installation because it will determine how other elements are located after and ultimately the success of the project.

8.5.1 MOUNTING SYSTEM INSTALLATION

Y-axes rest on top of a mounting system, this system is made of scaffolding feet, nuts and other adjustment elements that are attached to the axes in specific locations.

The mounting system is different between Y1 and Y2 because Y1 hosts the AHMS. Y1 is therefore wider than Y2. The image below shows the components in a Y1 system:



8.5.2 Y MOVEMENT

Once all feet are assembled to the 4-module segment truss it is possible to start moving the axis to its preliminary location before calibration.

The printer includes a system that allows personnel to manually move Y-axis modules in sections. This tool is called "Truss Jack Wheels".

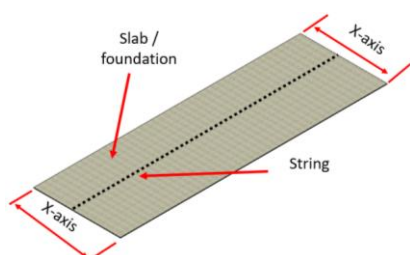
Truss wheel jacks get secured to the corners of the finalized 4 module axis, it is important to highlight that these tools should **only** be used for Y truss assemblies of 4 modules or fewer, **or** 2 modules with Y-carriages installed.

⚠ Important! It is imperative to follow the recommendation above not to deform the tool. If the Y-truss with the Y-carriages flip, there could be potential damage to the equipment and operators.

When adding 4 more modules to an already levelled section of truss, you first line up the two faces you will join and loosely install the four M16 bolt, you then level the truss using the same method as before, finally the two fish plates should be installed followed by tightening the M16 bolts to 250nm.

8.5.3 Y CENTERING

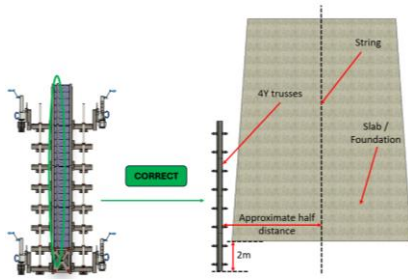
This procedure ensures the machine is centered in relation to the slab/printable area and it must be followed in detail, step-by-step, otherwise the machine will not be mechanically calibrated. Mechanical calibration is the most important step for the BOD3. In case the steps are not correctly followed the machine X-axis and Z-connection system will be impossible to install. Additionally, possible mechanical malfunctions will occur when Y-carriages start operating.



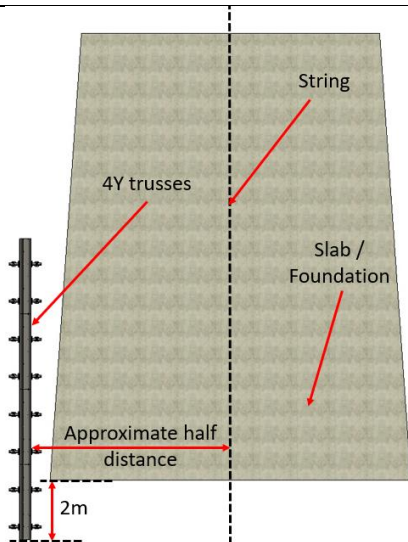
1. Measure the exact dimensions of the slab/foundation/print area across the x axis and mark the center point as shown.



2. Once the center point at each end of the slab/printable area has been determined, use a string to mark the center line along the Y-axis.

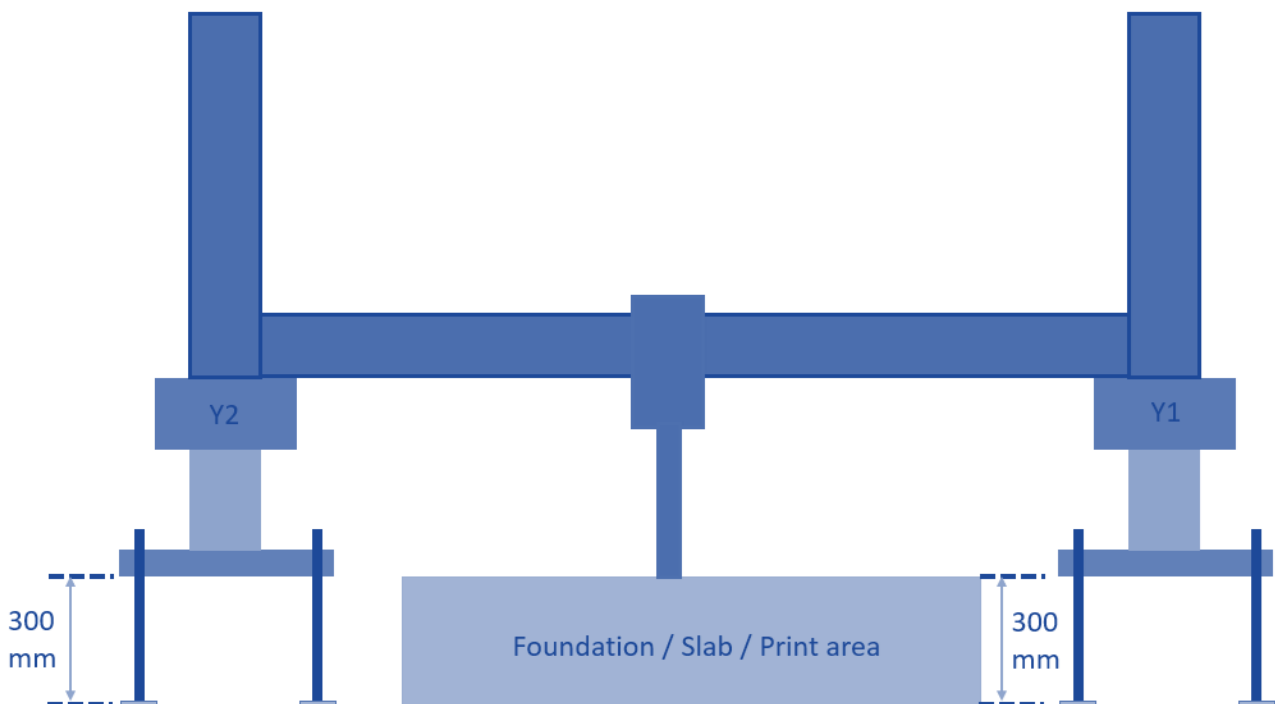


3. Ensure that the tooth-rack is oriented to be furthest from the slab/foundation/print area as shown.



4. Position the Y2 truss assembly at half of the parallel distance for the intended X-axis (as per X axis config). See table and graphic at Y1 to Y2 Distance and Alignment section.

5.

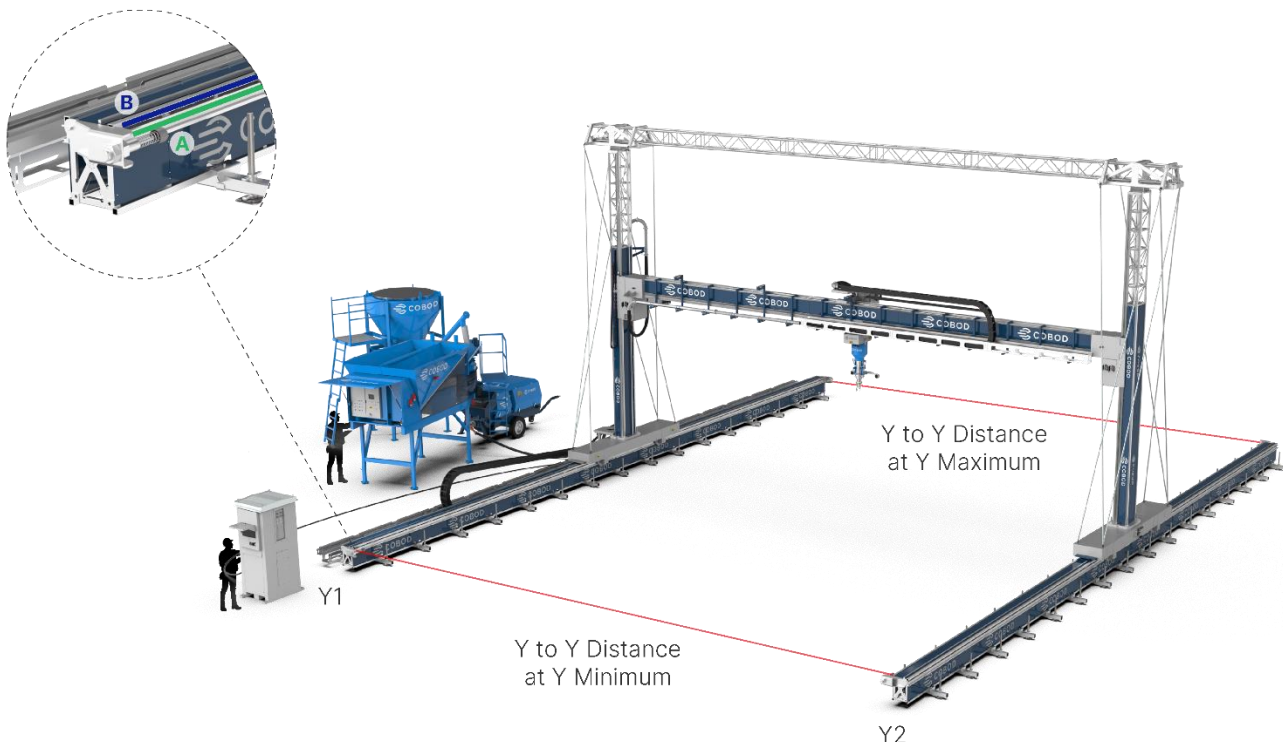


8.5.4 Y1 TO Y2 DISTANCE AND ALIGNMENT

The following section outlines the process for determining the distance and placement between Y1 and Y2 trusses. Ensure that the Y-trusses are parallel and their ends are aligned, with neither end extending beyond the other. Use a multi-line laser to validate this alignment. Refer to the table below to confirm the distance between the Y1 and Y2 tracks.

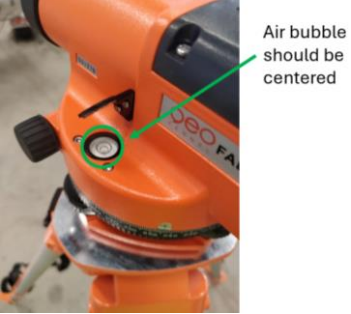
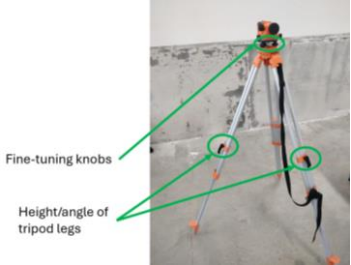
For accurate measurement, it is most recommended to use the U-Profile (A) as the reference surface. Apply masking tape on the side of the U-Profile for the distance laser to point to. If light conditions cause reflections on the U-Profile (A) surface and produce errors with the distance laser, use the Square Tube (B) as the reference. Take measurements at both the Y minimum and Y maximum positions.

Note: The allowed tolerance for the measured distance can be up to 3mm longer (+3mm), but it must not be shorter than the values specified in the table.



X Configuration	Reference Surface & Distance in mm	
	A) U-Profile	B) Square Tube
2	6507	6483
3	9033	9009
4	11559	11535
5	14085	14061

8.5.5 LEVELING DEVICE CALIBRATION

	1. Place the height levelling tripod in a fixed and stable position outside of the slab/foundation/print area.
	2. Mount and fasten the levelling device to the tripod.
	3. Referencing the position of the air bubble relative to the inner black circle, calibrate the levelling device to be horizontal using the fine-tuning knobs and the height/angle of the individual tripod legs.
	4. To calibrate the levelling device, the air bubble should be centred when viewed from above.

8.5.6 Y AXIS HEIGHT CALIBRATION

Mechanical calibration of the BOD3 refers to the feet to slab distance and the levelling the Ys height with the help of a calibration tripod that is typically used by surveyors in traditional construction.

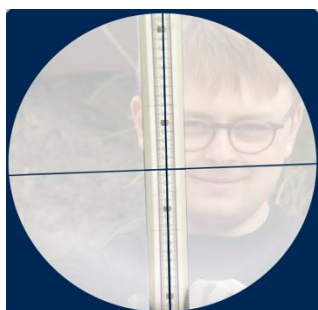
For the levelling of the Y-axis, we will only adjust the four feet at the corners of the truss, the remaining legs can be raised up, so they don't interfere with the process.

⚠ Important! If the machine scaffolding feet are installed on the same foundation/slab as the intended print, they need to be adjusted so that the underside of the crossbeams are maximum 10 cm from the slab, to ensure then nozzle can reach the ground without losing any printing height.

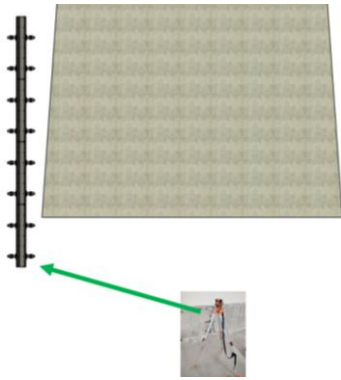
If the machine scaffolding feet are installed outside the foundation/slab, the height of the slab needs to be known and accounted for. For example, if slab is 300mm higher than the installation surface, the underside of the crossbeams should be this height from the ground. If the slab height exceeds the dynamic range of the scaffolding feet (300mm), that will translate to loss of printing height.



1. Place the levelling ruler vertically on the slab/foundation/print area, then, aim the levelling device telescopic viewfinder towards the long face of the levelling ruler.



2. Note and record the number on the levelling ruler that aligns with the crosshair.



3. Place the levelling ruler vertically on top of the outer most crossbeam



4. Rotate the levelling device so that the telescopic viewfinder is aimed at the levelling ruler as shown.



5. Find the height reference noted in the previous step and subtract 80mm from this number. Rotate the truss wheel jack handle accordingly so that the telescopic viewfinder crosshair is aimed at this new number (as per previous step) on the levelling ruler.



6. Repeat this procedure for each of the remaining crossbeams with truss wheel jacks attached. Once the height of all truss wheel jacks are identical, go back and double check each height value.

8.6 SAFETY CONSIDERATIONS Y-CARRIAGES

The BOD3 comes with Y-carriages mounted on the Y beams now of reception. However, it is important to secure the elements below before considering the Ys operational.

8.6.1 INSTALLATION OF Y SHOCK ABSORBERS (END STOPS)

Using 2x M16X110 bolts, 4x M16 wedge lock washers and 2xM16 nuts, install the Y-truss End stop A inside the print area of the Y1 & Y2 truss ASM using a torque wrench and torque tighten it at the value equal to 175Nm. Repeat for opposite side.

⚠ Attention! the Y-Truss end stop A is installed at the front ends of the Y-truss ASM and the Y-truss end stop B is installed at the back-ends of the Y-truss ASM.



8.6.2 CALIBRATION OF THE BEARING MOUNT

⚠ Important! CAM followers should be kept disengaged during transportation and should only be tightened after ZCS bracket is installed. If they are tighten before, there is risk of damaging the bearings of CAM followers.



1. Using a size 8 Allen key turn the CAM follower found on the Y-carriage Bearing mount until it engages with the Y-truss rail.

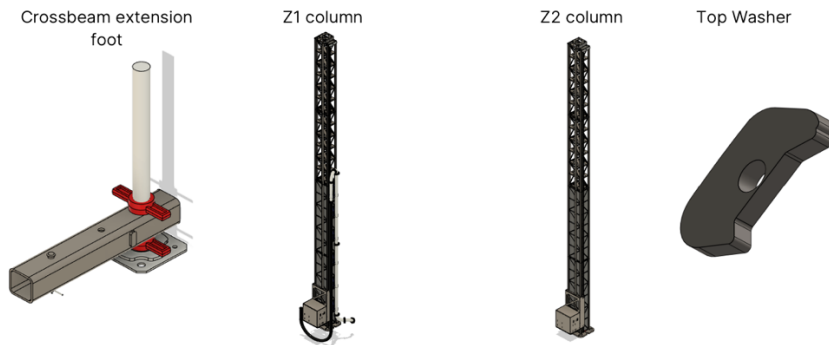


2. Once CAM follower is engaged, hold it place by using the size 8 Allen key and by using m18 spanner tighten the m18 fastener.

3. Repeat the previous steps on all 8x CAM followers found on the 8x bearing mounts in total (4 per Y-carriage) on both Y-carriages (e-chain and no e-chain side).

8.7 INSTALLATION OF Z1 AND Z2

Mounting the Z-columns is a process that requires a lot of attention due to the lifting involved. The goal is to lift each column as slowly and precisely as possible and place them vertically right on top of the Y carriages. The use of a crane is highly suggested. Main components:



1. Install the 6x crossbeam extension foot, 3x on each side of the Y-carriage e-chain side ASM as presented in picture.



2. Before you lift the Z1-column using a crane make sure that the Z-carriage is positioned **150mm** from the base plate. (if the carriage is higher than 150mm there is risk of rolling it). For the installation of Z1 and Z2 in BOD3 we use 2 x M30 anchor rods (Y1 E-chain side) and the rest are secured with M30 bolts. Due to this, Z-carriages can go very low.

Layout

The Z Control Box can be used to power and move. all Z-carriages. The intended use of the box is to manually move the carriages onto the Z-axes or to align the height of the carriages. This is done when. Installing the printer to create a levelled base for the ZX boxes or when the printer is dismantled for shipping, storage etc.

Connecting the box

The box should safely be connected to a 3 phase, 32A power outlet with enough cord needed for the appropriate movement of the Z carriages. The heavy-duty plug should be connected to the input socket on the Z carriage. Ensure that no other connections to the carriage box are present. Whenever power is switched on, the yellow “PLC ON” lamp should light up.

Button Descriptions:

- The box contains a 3-stage switch and 4 buttons. The 3 stage “Mode” switch has the following modes:
 - **Left:** No movement
 - **Middle:** Slow movement
 - **Right:** Fast movement
- The green start button is used to power on and start the carriage motor.
- The blue up and down buttons move the motor continuously when pressed.
- The red stop button is used to power off or reset the motor box. It will also flash if an error is encountered.

Start Up

Once the box is powered up, the yellow PLC ON lamp should be on and the green START button should be flashing. This indicates the box is ready to connect to a carriage.

- Press and hold the START button for 2 seconds, until a click from a relay is heard meaning the power is on. After approximately 10 seconds, one of the following 3 scenarios could happen:
 3. All the buttons light up. The box is now ready to control the connected Z-carriage.
 4. Blinking red stop button. This means that the remote box has made configuration changes to the Z-carriage and now needs to power cycle. To do this press the red stop button once and wait around five seconds. Then hold the green button for two seconds and then the buttons should light up and the box is now ready to control the connected Z-carriage.
 5. Blinking red stop button but the steps in scenario 2 do not produce a functioning result. Please contact COBOD technical support.

Normal Operation

- When the blue buttons are lit, the driver should be ready to move the carriage. If the MODE switch is set to slow, the maximum speed is set to 10mm/s. In fast mode, the maximum speed is 40mm/s with higher acceleration.
- The carriage should only be moved when it is safe to do so. Ensure cables are not caught during movement of the carriage.
- To disengage the drives, press the red STOP button once. The drives can be engaged again with a single press of the START button after this.
- To turn the box off, press the red STOP button once to disengage the drives, then press it a second time to turn off the power to the carriage. Only after a click from a relay is heard is it safe to remove the heavy-duty connector from the box.
- To start up the carriage again, the green START button must be held for at least 2 seconds.



6. Lift the Z1 column. Make sure that the steel chains and or lifting ropes used for lifting the Z1-column are inspected on the spot. in case they found to be damaged or worn make sure you replace them on spot.



7. Position the column on top of the Y1 carriage as shown in the picture.



8. Add 1x top washer, 1x m30 washer and 1x m30 nut for each m30 threaded rod as it is shown in the picture attached.



9. Using a cherry picker and or a boom loader with a basket (and or scaffolding) detach the Z1-column from the crane. **Read all safety sections in this SOP before operating.**

10. Repeat the previous steps for the installation of Z2 on top of Y2.

8.8 INSTALLATION OF XUC, X-AXIS AND PRINTHEAD

Success in these operations is conditional on the precision of the previous works as well as a clear plan on the orientation of all items (please see *Orientation* chapter).

Fitting the XUC carriage on the X-axis and the X-axis on top of the Z-carriages requires precision and caution. Below is an overview of the operation before a more in depth description further below.

Mounting of XUC-carriage:

XUC should be centered on the X-axis for keeping the truss stable while lifting.

Rigging and lifting X-axis:

Using lifting straps, lift the X-axis as straight and level as possible. Pay special attention if the axis is rotating either forwards or backwards. Readjust the lifting straps to get it level in accordance to operation conditions. Risk assess in advance.

Placement of X-axis:

Slowly and carefully place the X-axis on top of the Z-carriages.

Securement:

After placing the X-axis, use the mounting brackets and bolts to secure it in place. Mount the shock absorbers before undoing the lifting straps.

8.8.1 INSTALLATION OF XUC-carriage

Mounting the XUC on the X-truss is a delicate task that requires precision.

Remember that the X-axis is not originally shipped with the carriage mounted, meaning it arrives divided in in two halves, the XUC carriage needs to be mounted and at the end, both parts are reassembled into one final X-axis. The printhead is not mounted currently.

The X-axis is the most delicate of all axes and should always be mounted on top of special stackers to prevent damage, one stacker per module will evenly distribute loads.

To mount the XUC-carriage on the X-truss you will need the tools described for the assembling/disassembling trusses section above, a telehandler or crane to lift the trusses/carriage on top of the pallets and a mobile pallet lifter with reasonable lift capacity.

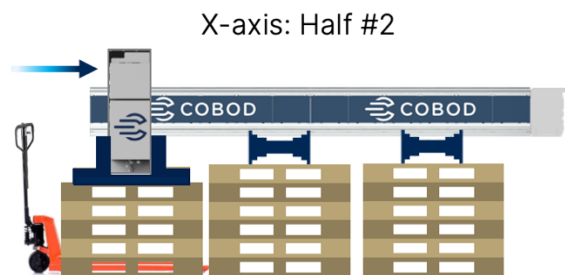
1. Identify and place the two halves of the X-trusses on top of pallets as seen in the image below, note how the second half was positioned in a way with enough space to place the X-carriage.



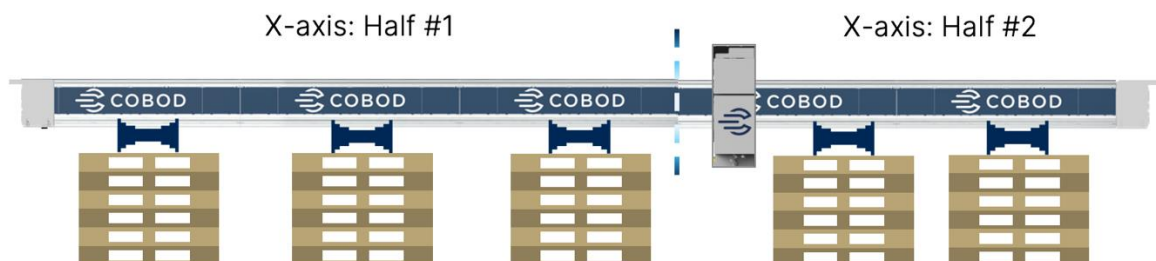
2. Identify and place the X-carriage on top of pallets with its special stacker in place.



3. Accommodate the pallet lifter next to half #2 and lift the pallet so the X-carriage matches the truss profile, once the items match, carefully slide the carriage inwards and remove the special stacker. Remember to unplug the driver.



4. Once the carriage is on the truss and stable, remove the special stacker. Assemble the other half and slide the X-carriage to the middle of the truss to balance the weight and complete the process. Once the XUC-carriage is mounted in the middle of the X-axis, plug the driver back in to avoid sliding while lifting the full X-axis.



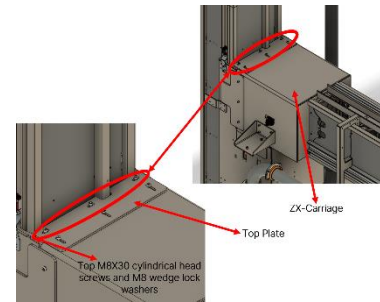
8.8.2 INSTALLATION OF X-AXIS

This section focuses in placing the X-axis on top of the Z-carriages. It is important to review the section *Orientation* before proceeding as it is common to install backwards, remember the printer has indicative stickers to make identification easier.

Important!

Before you lift the X-axis using a crane, make sure that you inspect the steel chains and or lifting ropes used for rigging. If worn or damaged, replace them before the lifting operation. Make sure that the X-carriage is centered on the X-axis. This is important for keeping the X-axis level and stable while lifting.

1. Using straps lift the X-axis as straight and level as possible. Pay special attention if the axis is rotating either forwards or backwards. Readjust the lifting straps to get it level. Slowly align X-axis with the Z-carriages. Install the X-axis on the Z-carriages as it is presented in the picture. There is around 6mm tolerance between ZX bottom facing flaps and Z-carriage, hence, it should be spaced evenly. ZX boxes must sit exactly in the middle of the Z-carriages. Remember that the orientation of the XUC matters.
2. Fasten the 3x m8x30 cylindrical head screws and m8 wedge lock washers on Z-carriages for each of the ZX – carriage top plates. (look on the attached picture). Secure everything before removing the straps and crane/telehandler support.



8.8.3 INSTALLATION OF THE PRINthead

If there is not enough space for the printhead to be installed, go to master homing and master X, Y and Z axes to move the printer up to a position in which you will be able to install the printhead. Then install the printhead and proceed with homing U and E.

1. Place the Extrusion screw inside the hopper.
2. Place the printhead stand with the fully assembled printhead below the X-carriage.
3. Lower the X-carriage through Duet until it is approx. 5 cm above the hopper and the clamps can reach.
4. Attach the cardan joint with the Archimedes screw to the X-carriage shaft.
5. Secure the hopper to the X-carriage by locking all three clamps.
6. Turn off the printer and connect the plugs for the U-motor and the camera connections – turn printer on again afterwards.
7. Connect the hose.

8.9 Z-CONNECTION SYSTEM & DYNEMMA ROPES

Before starting this chapter, please review the *Mechanical Components* section of this document.

Installing the Z connection system is the final step in the mechanical setup of the printer.



As the brace goes on top of the Z-axes, a telehandler or crane is required. Since the brace needs to be fixed in position a cherry picker or scissor lift can be used. A certified work in heights employee for climbing is required.

8.9.1 INSTALLING Z CONNECTION SYSTEM



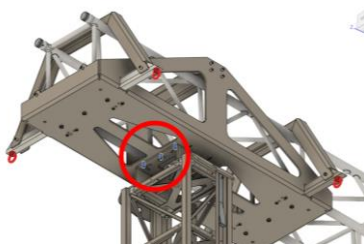
1. Attention! DO NOT SKIP!
Before you lift the Z connection system using crane make sure that you inspect the steel chains and or lifting ropes.
In case they found worn or damaged, you must replace them before the lifting operation.



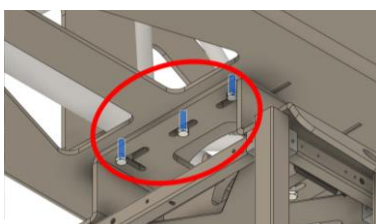
2. Lift the Z connection system as it is presented on the picture attached.



3. Install on the Z-columns as presented in the picture attached.



4. Using scaffolding / a cherry picker / a boom loader with basket, position yourself close to the Z1-column top hat and fasten the 6x M10X35 hexagon head screws and 6x M10 wedge lock washers (three sets are fastened on one end of top hat and the other three on the other end.)



5. It is suggested to have with you an M10X90 screw (same screw used for crossbeams) for correctly orienting and positioning the T-Bracket welded nuts on the Top Hat slots.

8.9.2 INSTALLING DYNEEMA ROPES

The dyneema ropes have three main components:



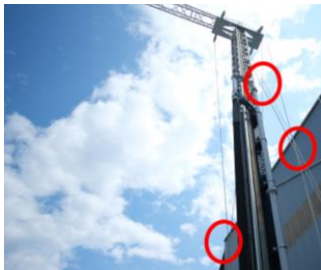
Dyneema ropes



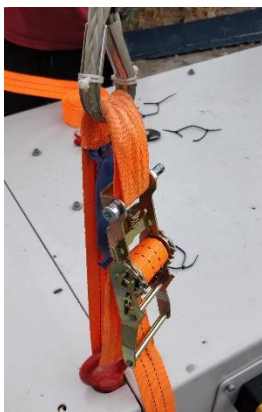
Ratchet straps



Tensiometer



1. The Dyneema ropes should be always connected in cross manner (see picture attached).



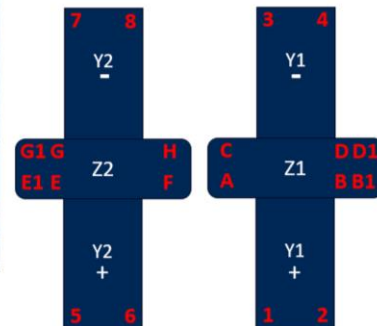
2. The connection at the Y-carriage is done with ratchet straps. Initially, just connect it. but **do not** in any case tension it. see picture attached.

For further instructions on this specific topic please contact techsupport@cobod.com

3. It is a must to follow the below schematic on how to correctly position each single dyneema rope to its pre-defined designated area on the y-carriage e-chain side (Y1) & y-carriage no e-chain side (Y2). Dyneema ropes schematic - **Back side**



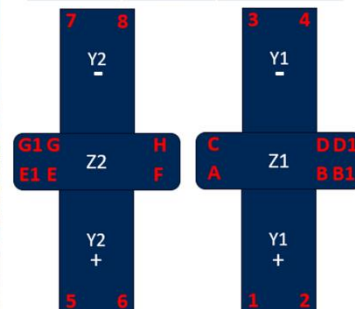
Column Name	Color	Y- Carriage Lifting Eye
Z1 - A	Red	2
Z1 - B	Yellow	1
Z2 - F	Red	5
Z2 - E	Yellow	6



Dyneema ropes schematic – Front side



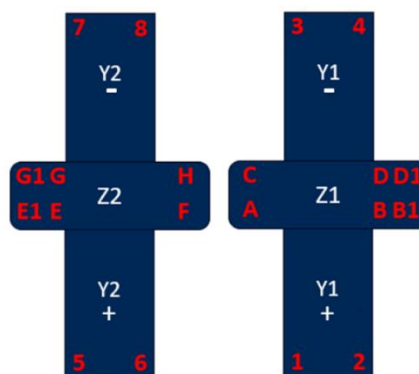
Column Name	Color	Y- Carriage Lifting Eye
Z1 - C	Red	4
Z1 - D	Yellow	3
Z2 - H	Red	7
Z2 - G	Yellow	8



Dyneema ropes schematic – Z1 side



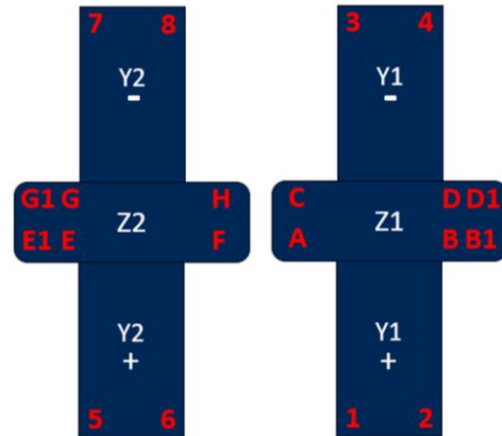
Column Name	Color	Y- Carriage Lifting Eye
Z1 - D1	Lilac	2
Z1 - B1	Green	4



Dyneema ropes schematic – Z2 side



Column Name	Color	Y- Carriage Lifting Eye
Z2 – E1	Lilac	7
Z2 – G1	Green	5



- Start Tensioning the Dyneema ropes one at a time. It does not matter from where you start as long as you tension in cross manner. For example, if you tension Z1 – A - 2, then you will need to tension Z1- C- 4. Then Z1 – D -3 and then Z1 – B -1. The Z1 – B1 – 4 and Z1 – D1 – 2.



- Position the Tensiometer on the Z1 – B - 1 dyneema rope as it looks on the picture attached.



- Then start pulling the ratchet strap lever until the Tensiometer weight indicator reaches 400kg.

- You can proceed by doing the same on Z1 – C - 4. Once you finish it move on with the rest as it is suggested above.

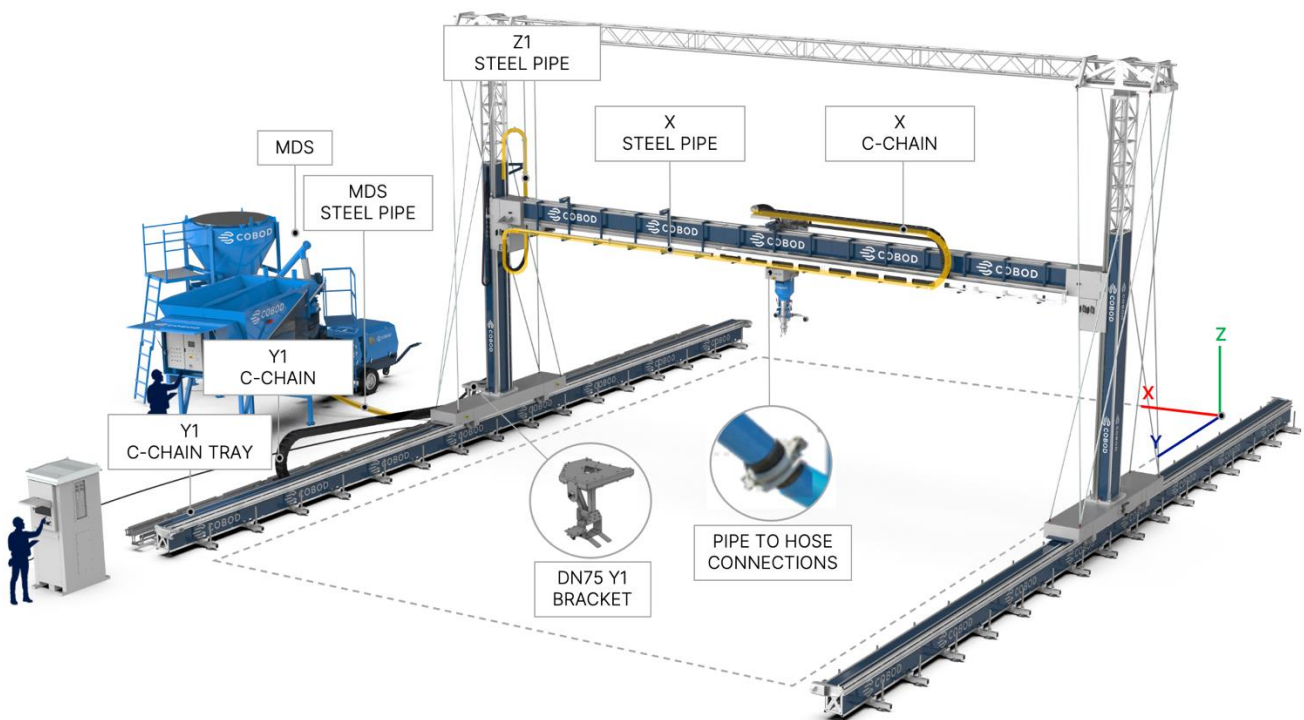
8. Repeat the same steps for tensioning all Z2 Dyneema ropes.

9. Once both sides have been tensioned, repeat the tensioning procedure to 600kg.

10. It is suggested that this process is repeated once a day and micro-tightening in case of a need the ropes.

8.10 AHMS INSTALLATION

Before starting this section, we recommend reviewing the *Mechanical Components* section in this SOP. The items below are an overview of the AHMS path and how to communicate about their specific location.



The following tools are required to install the AHMS:

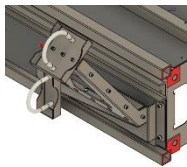
Large flat-headed screwdriver	Clamp	DN75 hose guide tip	Combination wrench set	Hex key set	IGUS hammer	Torque wrench & socket set
						
GUS chain opener	Boom loader and operator	Crossbeam alignment tool	Silicon spray	Lifting straps (min. 0,5T)	Large combination wrench (for M30 nut/size 46)	
						

The following sequence should be followed to install the AHMS:

1.Aligning and mounting Y1 mounting system.



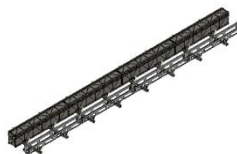
2. Installing Z hose fixed end (FE) strain relief on Z1.



3.Installing Z pipes and Z hose fixed end on Z1.



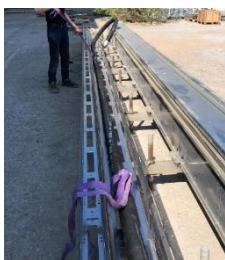
4. Installing AHMS guide trays on Y1 crossbeams.



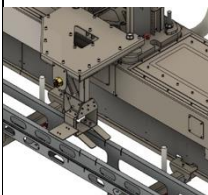
5.Assemble and install Y axis AHMS drag chain.



6.Inserting Y hose into Y axis AHMS drag chain.



7. Installing DN75 Y bracket assembly.



8.Assemble the X axis AHMS drag chain.



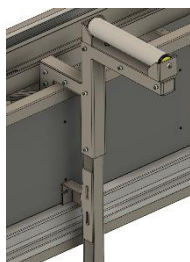
9. Inserting X hose into X axis AHMS drag chain.



10.Installing X axis AHMS hooks on X axis.



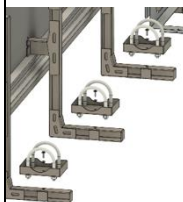
11. Installing X axis truss hook support bracket ASM.



12. Installing X axis guide trays.



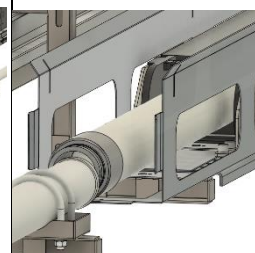
13. Installing X hook pipe holders.



14. Installing X axis steel pipes.



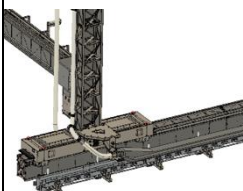
15. Installing X axis AHMS drag chain & hose assembly.



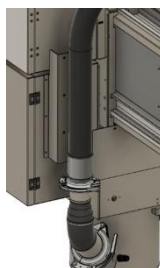
16. Connecting Z hose moving end to X axis pipes.



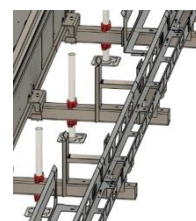
17. Fastening Y axis drag chain moving and fixed ends.



18. Connecting the X hose moving end to the hopper.



19. Installing Y axis roller mounts.



20. Connecting material source to the Y axis hose.



8.11 ELECTRICAL ASSEMBLY

Please reference the *Electrical Components* section of this document with special attention to the carriage connections and wiring diagram.

The static cables and E-chains are connected to the printer after the mechanical assembly is done.

The E-chains are quite heavy and are easiest to handle with a crane/telehandler. Before you lift any, make sure that you inspect the lifting chains/straps, so they do not pinch or damage any external component while lifting. In case lifting chains/straps are found worn or damaged, you must replace them before the lifting operation.

E-chains need to be rolled out for assembly before placement and a clear plan needs to be discussed in advance to maximize efficiency. Operators must check which end needs to go where and which way the E-chain will be unwrapped.

8.12 DOSING SYSTEM CONNECTION

**Please review the *DUAL DOSING SYSTEM* chapter for more in depth information.
For installing the three pneumatic manifolds through the system:**

1. Place pneumatic manifold Y over the M30 rod and re-fasten with the M30 washer and M30 nut.
2. Position pneumatic manifold Y and fasten to Z-X1 box with M8x30 bolt and M8 washer.
3. Locate pneumatic manifold X, then, on the underside of the Universal Carriage, unfasten 2 x M8x20 bolts and M8 washers attaching X carriage shielding left to the Universal Carriage.
4. Position the pneumatic manifold X as shown, and fasten to the Universal Carriage with the 2 x M8x20 bolts and M8 washers.

8.13 PRINTER HOMING, INTERNET, AND CAMERAS CONNECTION

8.13.1 MASTER HOMING

Homing means to slowly move the printer to its machine origin “origo”. Please consult the SoftNA chapter 6.1.8 for further information. In general, automatic homing works for the X-axis, but for Y and Z it continues to be a manual process. Move the Y or Z to desired 0 position and click “Master” for each one.

Master homing is to be performed each time the machine has been moved and re-assembled on a different site. Before initiating homing, make sure the mechanical printer set-up is on par with provided installation instructions. Also, make sure there are no obstacles in the print area and that both the Limit Switches and EndStopBracket are installed correctly.

8.13.2 LIMIT SWITCHES AND END-STOP BRACKETS

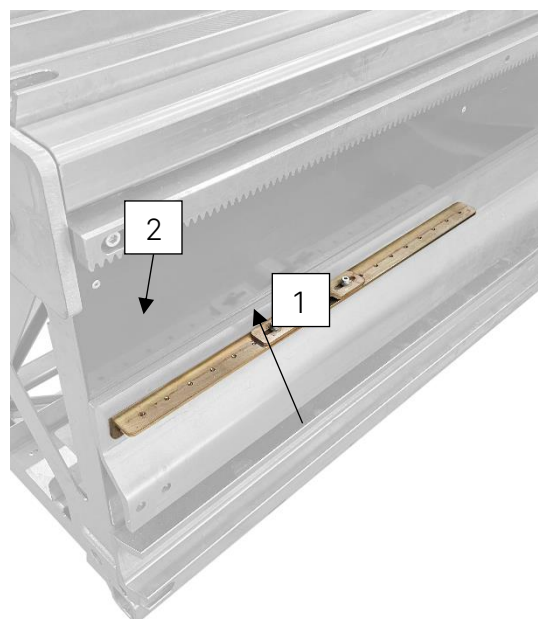
Ensure that the shock absorbers are installed correctly for both Y axes. Before using the automatic homing function, carefully move the carriage with the Limit Switch over the bracket until you hear it click. By default, only the Limit Switches are active, but the remaining ones can be activated as well.

To adjust the bracket, simply loosen the screws and move the bracket to the wanted position along the mount. The position of the bracket will have an impact on your maximum printable area – the further from the end of the Y-truss, the larger the decrease in printable area.

The Limit Switches are only active when performing Homing and will not detect being pushed in any other case.

⚠ Important! After performing either homing or any other movement via Soft-NA, remember to click Get Machine Position in Duet to update the machine position to the correct coordinates.

Axis EndStopMount (1) and -



MASTER X

During X homing, the printer will move along the axis towards the negative direction until it reaches the limit switch.

Once the BOD3 is powered on and all axes are aligned, go to Machine Setup, enable Homing Mode, and click on Master X. Upon completion, the system will retain the origin by keeping track of any motor movements, even when the printer is powered off.

MASTER Z AND Y

To set the Z or Y origin (the lowest Z or furthest Y point the printer can reach), carefully move the machine (fully assembled including complete printhead) for the nozzle to barely touch the ground level for Z. To master Z, disable Duet mode, go to Machine Setup, enable Homing Mode, and press Master Z. In BOD3, mastering Y works same as Z - position printer manually, hit master in SoftNA, which just takes current position and assumes it as 0.

MASTER U

While having the printer powered on and Duet mode enabled, rotate the U-axis so that the teeth of the nozzle are aimed at the Printhead E-box and the 'front' (flat side) is parallel to the X axis. Then, via Soft-NA, disable Duet mode, go to Machine Setup, Enable Homing Mode and press Master U. To validate, turn Duet mode back on and go to the Duet web interface. Via the Machine Movement selection press Get Machine Position. U-axis value should be equal to 0 or 360 at that position.

MASTER E

Home E is used to set positioning of the highest point of the mixing arm regarding the level sensor and the level of material in the hopper on the printhead. The Home E setting is to counter for

the height of the mixing arms to determine the correct material level in the hopper and thereby give the pump the signal to deliver material to the printhead.

To **Master E** the highest point of the mixing arm needs to be positioned right underneath the material-level-sensor which is in the middle and front of the printhead and then homing the E in the machine settings.

Follow steps below:

1. Install the printer and the printhead.
2. For safety reasons, keep the printer turned off for this step: Turn the extruder screw into position – the highest part of the mixer arms should be right below the sensor on the bottom of the X-carriage.
3. Turn on the printer.
4. Enable drives.
5. On the HMI (Screen, SoftNA) go into the “Movement” tab and “engage the drives”.
6. Next in SoftNa, go to “Machine setup” tab and press the “Homing” button to activate homing, and then press “Home E”.

Now that the E is homed the printer will filter out the height of the mixing arms and will give a stable reading on the material level in the hopper.

8.13.2 CONNECTING TO A PC OR TABLET

This section describes how to connect a PC and/or tablet either via Ethernet or Wi-Fi to the printer. If using a tablet (or a PC without an ethernet port) it is only possible to use Wi-Fi unless having a dongle with an RJ45 (ethernet) port.

- We advise not to use a Macintosh or Linux PC. Use a Windows PC – only Windows can run COBOD Slice.
- It is possible to use any tablet if it can run a browser, preferably Edge, Chrome, or Firefox.
- The best PC solution for this application is a tablet PC with a detachable keyboard for easy maneuvering while printing.

DIRECT CONNECTION TO PC VIA ETHERNET (LAN)

Direct connection to the printer (LAN connection) is established by inserting a LAN cable into the ethernet port in the operators stand (OS).

The IP settings on your PC need to be set to “Automatic DHCP” (Default settings).

WI-FI CONNECTION TO PC OR TABLET

Wi-Fi connection to the printer is established by going to Wi-Fi and selecting the Wi-Fi broadcasted out by the printer. The name of the printer will be shown as “BOD3 *“company name”*P#”.

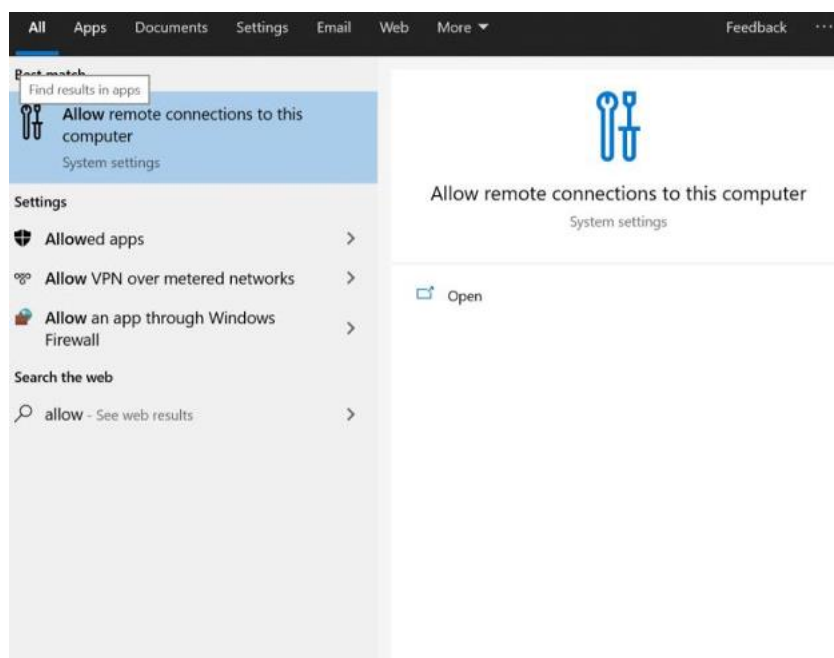
The IP settings on your PC need to be set to “Automatic DHCP” (Default settings).

REMOTE DESKTOP

This is a guide on how to establish remote control of the desktop on the BOD3.

1. Allow remote connections.

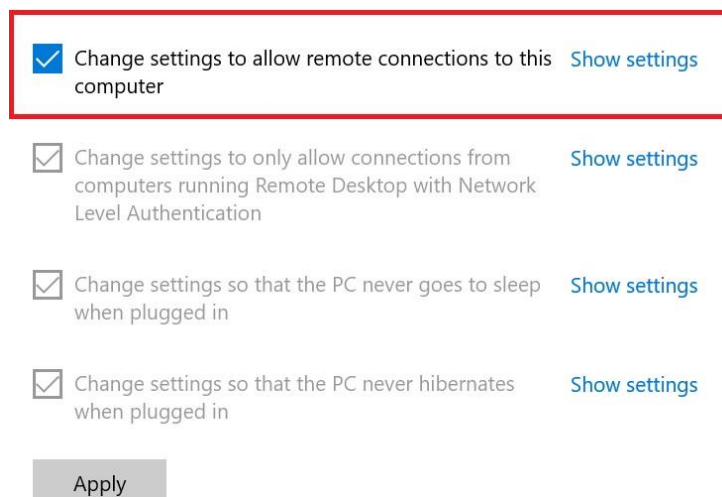
Make sure the setting on the IPC is allowing the connection of a remote desktop. Search “allow remote connections to this computer” on the IPC.



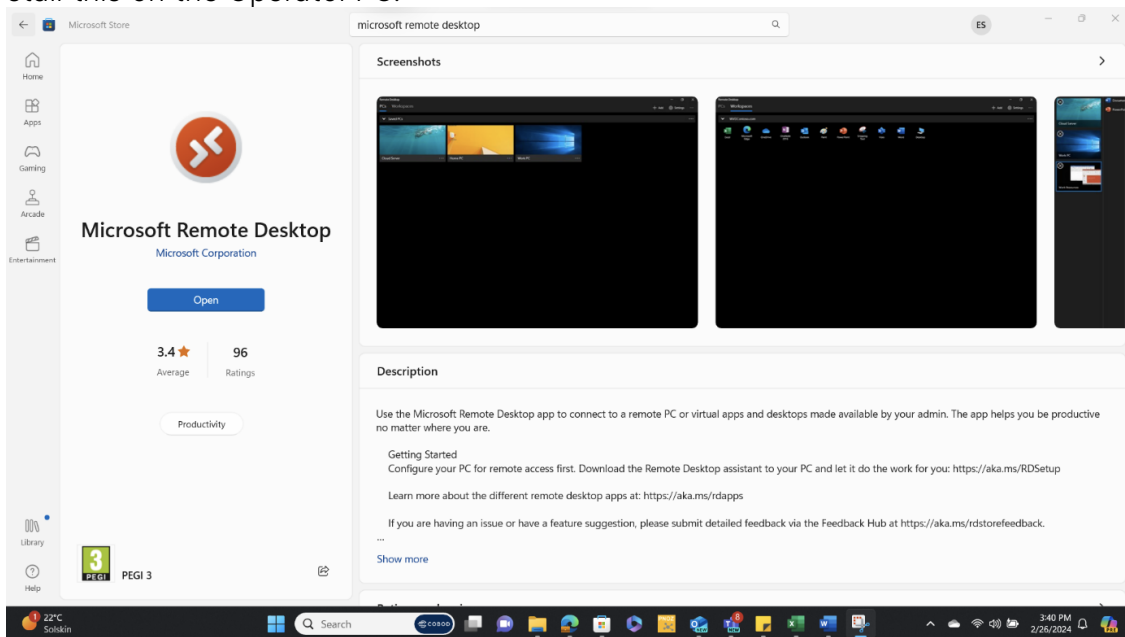
When in the settings, go to “Remote Desktop” and check off allow remote connections.

Remote Desktop

Apply the following settings to enable Remote Desktop and ensure machine availability.

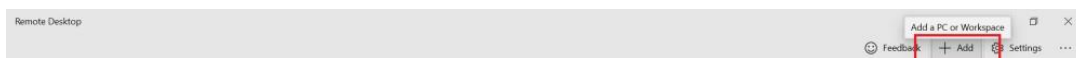


Go to MS Store and download Microsoft Remote Desktop. Select the App and install this on the Operator PC.



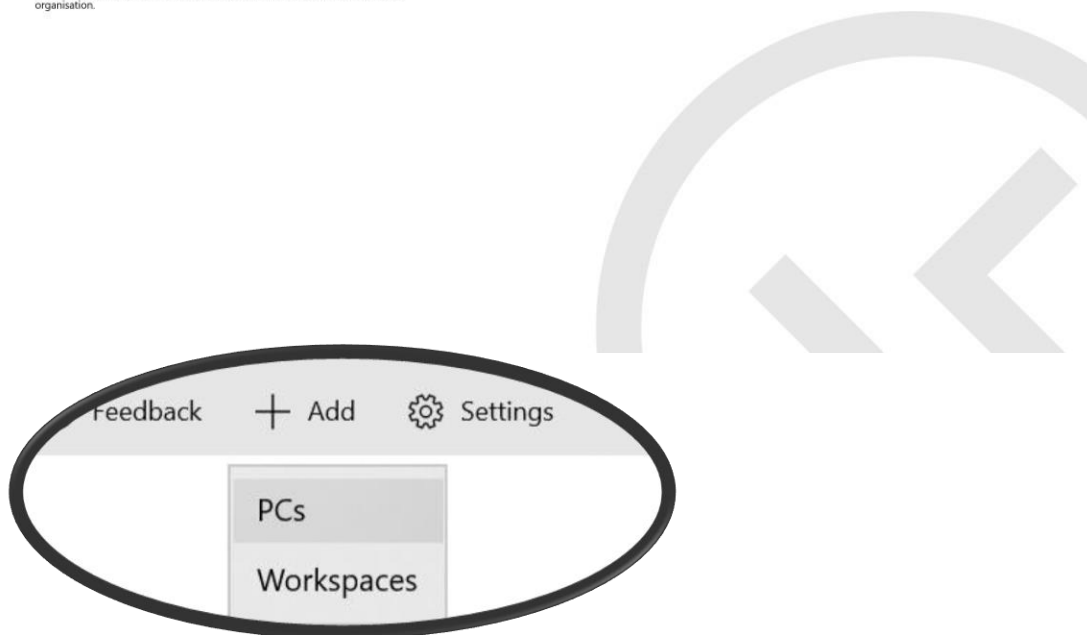
2. Download and install MS Remote Desktop.

Open "Microsoft Remote Desktop" and add a PC.



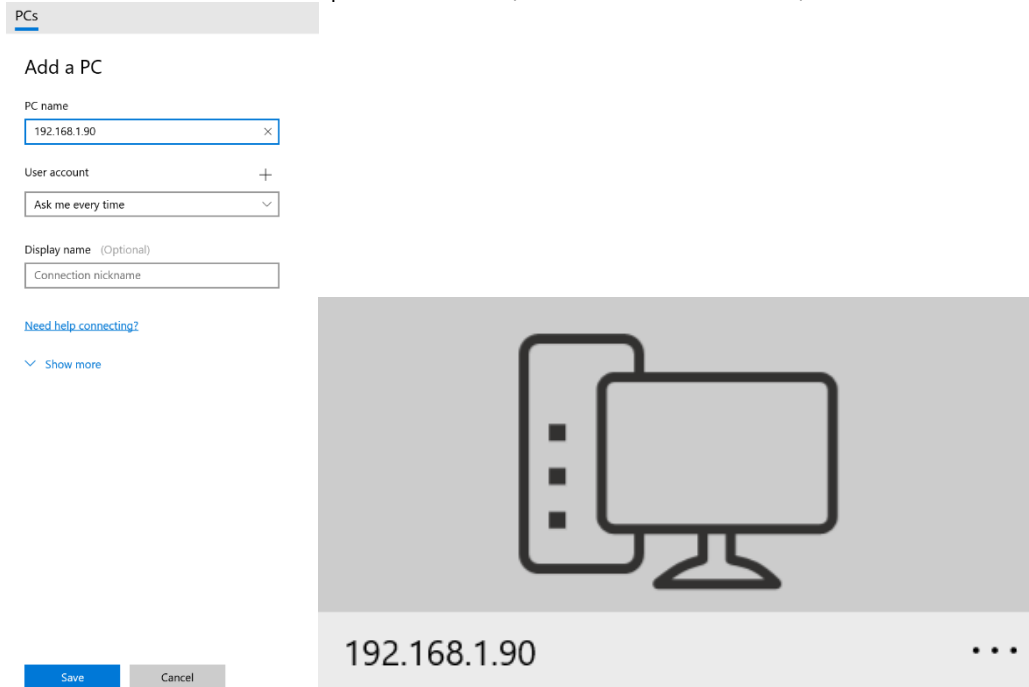
Connect to PCs and Workspaces

To get started, add a remote PC you want to connect to using this device. You can also subscribe to Workspaces to access apps and desktops provided by your organisation.



3. Connect to the BOD 3.

Enter the IP of the IPC and save. Create a stable connection to the printer.
Go online to the Desktop of the IPC. (Click on this window)



PCs

Add a PC

PC name
192.168.1.90

User account
Ask me every time

Display name (Optional)
Connection nickname

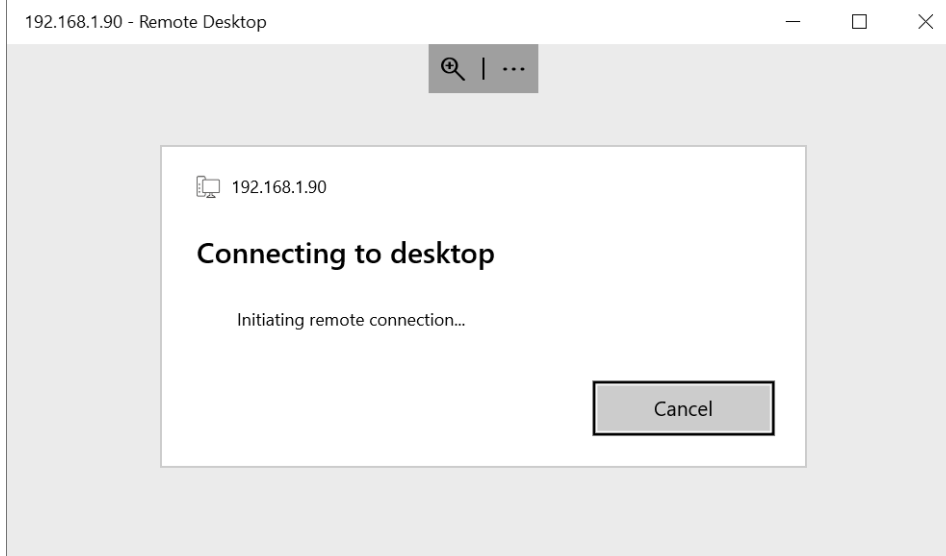
[Need help connecting?](#)

▼ Show more

192.168.1.90

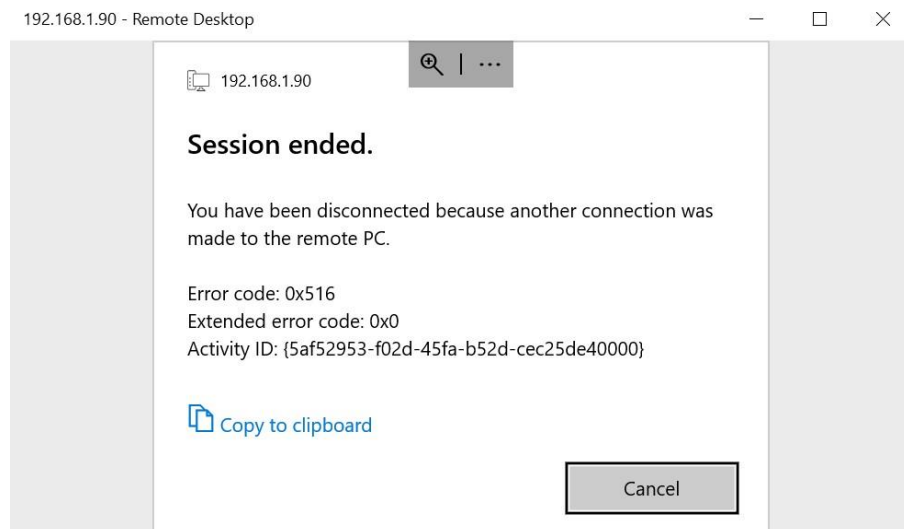
Save Cancel

A “pop-up” will emerge, and the Operator PC will try to connect to the IPC.



An additional pop-up will ask for the Credentials of the IPC, which is: Username: XXX, Password XXX (contact techsupport@cobod.com for more information).

If the connection fails, the “pop-up” will look like this:



Remote Desktop Troubleshooter:

If it does not work, check the following steps:

7. Check that the setting on the IPC is allowing Remote Desktop.
8. Check the connection by accessing 192.168.1.1 (Router) or 192.168.1.2 (Duet)
9. Check the IP in the Remote Desktop App is correct 192.168.1.90
10. Check that the Credentials are correct according to the specific printer.
11. If none of the above is solving the issue, please contact techsupport@cobod.com

REMOTE CONNECTION FOR TECH SUPPORT

Adding an internet connection for a remote link to the printer for tech support can be achieved by two different methods.

METHOD #1 – CABLE CONNECTION FROM ROUTER OR SWITCH

This method is usually done when installing the printer in a warehouse or workshop where there is a cable internet connection already installed. The way this works is by plugging into an existing internet outlet, either in the wall or from a router or switch and plugging the other end into the ethernet port on the main E-box (the one to the left, when looking at the front on the E-box).

⚠ Note! If there is a firewall or login credentials on this network, this will not work.
How to establish this connection:

1. Insert the RJ45 ethernet port into a port with internet.
2. Insert the other end of the internet cable into the ethernet port on left on the main e-box.

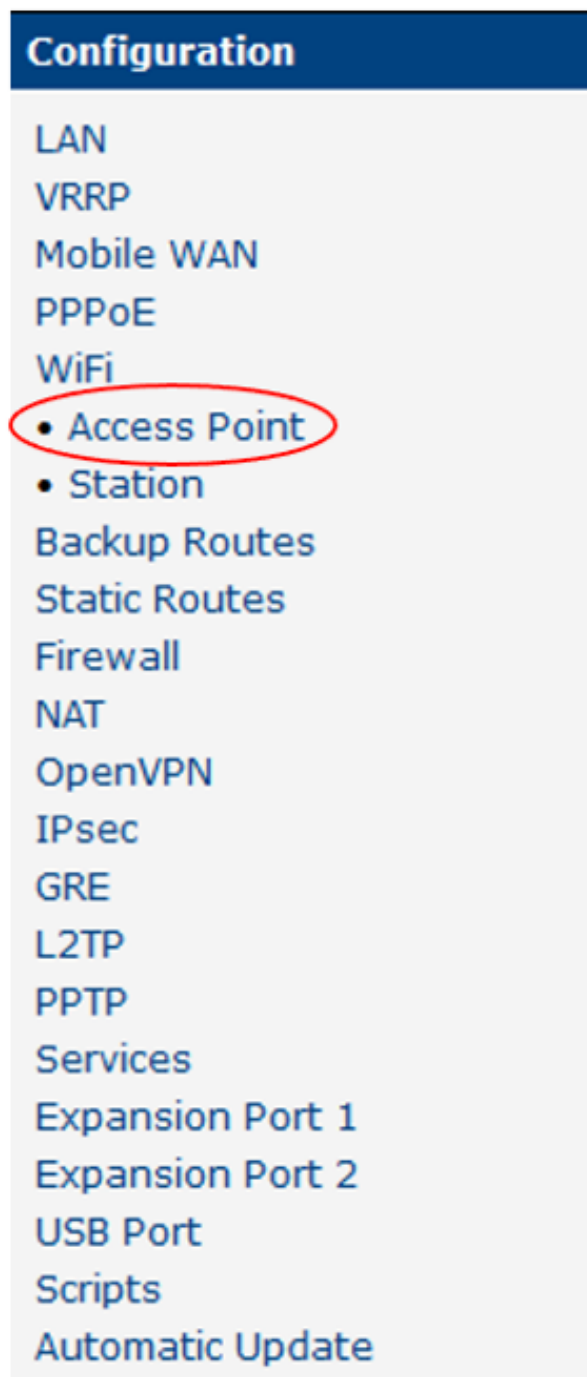
⚠ Note! This connection is the fastest and most stable.

METHOD #2

This method can be used on-site as one can use the Wi-Fi hotspot on a phone or mobile Wi-Fi router and connect to this. The way this works is by disabling the Wi-Fi access point on the printer's router and enabling the Wi-Fi station. When enabling the Wi-Fi station and inserting the credentials of the hotspot, the router will stream the Wi-Fi to the printer allowing remote access.

How to establish this connection:

1. Connect to the router via 192.168.1.1
 - Username: XXXX (contact techsupport@cobod.com for more details).
 - Password: XXXX (contact techsupport@cobod.com for more details).
2. Go into Wi-Fi under Configuration
3. Go into Access Point and disable Enable Wi-Fi AP. Click Apply – this will disable the Wi-Fi sent out by the printer's router.
 - (I.E *Customer Name* BOD 3)
4. Go into Station and enable 'Enable Wi-Fi STA'.



☒ Enable WiFi STA

	IPv4	IPv6
DHCP Client	enabled	disabled
IP Address		
Subnet Mask / Prefix		
Default Gateway		
DNS Server		

SSID:

Probe Hidden SSID:

Authentication:

Encryption:

WEP Key Type:

WEP Default Key:

WEP Key 1:

WEP Key 2:

WEP Key 3:

WEP Key 4:

WPA PSK Type:

WPA PSK:

5. Under "SSID" type in the name of your local Wi-fi network (or phone hotspot) that the printer will be connected to (here it is connected to the "COBOD A/S" Wi-Fi network)
6. Change the Authentication to WPA2-PSK and encryption to AES
7. Change "WPA PSK Type" to "ASCII Passphrase" and type in the password for the chosen Wi-fi network (in this case there is no password)
8. Click apply

Note! This will disable the Wi-Fi of the machine, so you can only connect to the machine via ethernet.

Note! If the hotspot (phone) is moved away from the antennas, the remote connection might be lost.

8.13.3 CONNECTING TO CAMERAS

The connection to the cameras is through a web browser and with the use of two IP- addresses.

Connecting to the cameras:

1. Open your web browser.
2. Connect to print head monitor cameras:
To access the cameras, open two new windows in your web browser. Enter the IP addresses below.
Camera 1: 192.168.1.200
Camera 2: 192.168.1.201
3. Accessing the IP addresses will direct you to the camera login page. Enter the username and password.

Username: XXXX (contact techsupport@cobod.com for more details).

Password: XXXX (contact techsupport@cobod.com for more details).

Entering the credentials will direct you to the live video feed. The cameras cannot be adjusted through the web interface. For adjustments of the camera please open the dome and carefully adjust the camera direction by rotating and tilting the lens.

8.14 SAT COMPLETION

Upon the first installation on-site COBOD will perform an Site Acceptance Test (SAT). After each project, before disassembling and packing the printer, the SAT can be used as a guideline to make sure the printer has passed the QA process before departure. The same verification will need to happen once the installation at the new location concludes and before starting operations.

The SAT includes:

- General safety checks
- E-stop checks
- Print head safety switches checks
- Performance test
- Movement directions on all axes check
- Movement on full axes check
- Material hopper sensor functionality and setting check
- Pump signal check
- Cameras test

9.PRINT PROCEDURE

All operational activities, including start up and shutdown, should happen in cooperation with the other team members in charge of the MDS. For all procedures described below you will find step by step checklists to reference on site as well.

9.1 STARTUP PROCEDURE

To turn on the printer, flip the power switch on the Operational Stand. Now, you will see the screen light up and shortly after, the login screen will appear. Login using the code specific to your printer. Soft-NA should open.

Using the yellow remote Operator Panel, turn the key clockwise and hold until the light above the XUC-carriage starts blinking yellow/red. Then, press the green button on the panel for a few seconds. The light will now switch to blinking yellow/green instead.

- If the light is not blinking yellow/green, but still yellow/red, follow the steps below:
- Make sure that none of the emergency stops are pushed/triggered by checking the Emergency Stop overview in the Movement page in Soft-NA.
- If an emergency button was pushed, release it, and go into the Troubleshooter and reset all errors.
- Again, firmly hold the green button, release, and check that the light is now blinking yellow/green.

Once the light is blinking yellow/green, go to the Movement Page in Soft-NA. Click Enable Drives and go into Duet mode by pressing the button below.

Check that all axes are green – this means that all axes are fully functional, and that the printer can be moved safely. If U has not yet been connected, ignore this axis.

If any axes show to be nonfunctional, try the following solutions one by one:

- Clear any errors in the troubleshooting page and see if this solved the issue.
- Restart the printer.
- Check all cables and ensure that all E-chains and static cables are correctly plugged in.

Go back to PLC mode and go to Machine Setup to check for any misalignment. Auto-realign if needed, to ensure your machine position will be aligned with the original origin. Exit Machine Setup, then go to Movement and enable Duet mode.

Connect to the printer either via Wi-Fi or Ethernet and go to 192.168.1.2 in your web browser to control the printer using the Duet interface.

9.2 OPERATIONAL PROCEDURE

Before printing, make sure that your G-code has been prepared in accordance with the instructions found in the *Modelling and Slicing SOP*.

1. Before moving, make sure to get Machine Position. Move the printer to the desired position for your job and choose the correct WCS for your print.

2. In the HMI check that all axes are green – this means that all axes are fully functional, and that the printer can be moved safely.
3. Connect to the printer either via Wi-Fi or Ethernet and go to 192.168.1.2 in your browser to control the printer using the Duet interface.
4. Upload your G-code via 'Upload job' in the bottom of the Duet interface.
5. Ensure to properly communicate with the materials operator to indicate the Dry Run is about to initiate so he/she can get prepared on their side.
6. Ensure a quality control process and tools are in place for the elements to print.

9.2.1 DRY RUN

Performing a dry-run means running a G-code file without any material in the system. This is done to ensure that the file is printable without any apparent issues, as you want to avoid having to pause mid print to fix any issues while having material in your printer system.

To perform a dry-run, move the printer to the approximate position you know the G-code will begin at, and press Print File. Throughout the first layer of the dry run, one should monitor the nozzle closely and ensure that the print path is aligned with its print base and there are no objects in the printing path. Stay close to an Emergency Stop in case the printer is heading towards any obstacles. Remember, that there are collision detectors in the printhead, which will cause the printer to pause if it collides with the foundation/print/rebar or any other objects appearing from it. However, avoid putting unnecessary force on the printer, if possible.

Dry run troubleshooting – what to do, if:

- Printer is skewed compared to base: if the path of the nozzle is off by a certain degree, this can be fixed by rotating the 3D model as much as needed and slice again.
- Nozzle is offset in X and/or Y direction: adjust your WCS in the config.override file (can be found in Duet > System). Remember to run the M501 command directly in the command bar after changing the WCS to load the changes.

During the dry run, you want to make sure that the nozzle will not hit any objects potentially appearing from the base (pipes, reinforcement attachments, wires, etc.). Let the dry run continue for at least 2 layers.

When printing on top of an already 3D printed structure, you must perform a dry run as well. Use the Slicing Range feature in COBOD Slice to create a file that begins at the height at which you previously finished. You can open the G-code directly in a text editor and see the coordinate at which the printer will start. Move the printer up to the height you will be printing at first, and then move to a X/Y coordinate approximate to the start point of the G-code. Using the command bar for this is very helpful.

When satisfied with the dry-run press Pause Print, followed by Cancel print.

9.2.2 PRINTING

Before initiating a print session, ensure that the entire team is ready and that everyone is aware of their area of responsibility. Communication is key when it comes to running a print operation – if needed, communication can be aided using two-ways radios (walkie-talkies) or field headsets.

You are now ready to pour the already prepared slurry into the pump and start pumping material towards the printhead:

- On the materials section in the HMI check the hopper level settings. A good starting point would be 60 as lower level and 65 as the upper level. Adjust this during the first couple of layers. The goal is to have a consistent mixing of the material in the hopper and have a level that is as stable as possible.
- Move the printer to an area where you can pour material and extrude until the material quality is satisfactory.
- Once material is ready, press “Print again” and the machine will start printing.
- Carefully monitor the speed, extrusion rate and U-axis during the print.

9.3 SYSTEM SHUTDOWN

This section will summarize the appropriate sequence to power off the machine. At this point in the process, everyone is aware cleaning operations are about to start. For a more extensive understanding of cleaning please reference the upcoming section *Cleaning Procedure*.

Disassembly for cleaning summary:

1. In the HMI turn off the pump signal output.
2. Make sure there is no pressure in the system before the next step.
3. Disconnect the concrete hose from the hopper.
4. Now manually extrude until the hopper is as empty as possible.
5. Move the printer so that the hopper is centered in the printhead stand but still a few centimeters above.
6. Turn off the printer using the main power switch on the E-box and disconnect the U-axis plug. It is important to place a cover not only on the plug but also on the socket on the X-carriage for protection. **Failing to turn off the power before disconnecting this plug can cause damage to the machine's electrical components.**
7. With the printhead disconnected from the printer loosen the three red clamps and carefully lower the printhead into the printhead stand.
8. Turn on the printer and carefully raise the Z-carriages to get access to the extruder screw.
9. Press an E-stop in the XUC-carriage before performing the next step.
10. Once E-stop is active, carefully disconnect the extruder screw from the cardan joint and take away for cleaning.
11. Ensure the strain relief chain is engaged and carefully loosen the two red clamps on the assembly to remove the pipe and the U-axis assembly.
12. Bring all the parts to the cleaning station.

10.CLEANING PROCEDURE

Definition

Cleaning your 3d printing system is vital to ensure productivity, expand equipment longevity and produce high quality prints.

As stated in the section of this SOP *Printer Areas*, the printable area requires a cleaning space to be considered since the project design stage. An area within the printable space is left clear in the Y+ or Y- side to allow the X-axis to be lowered so the PO can clean the printhead daily.

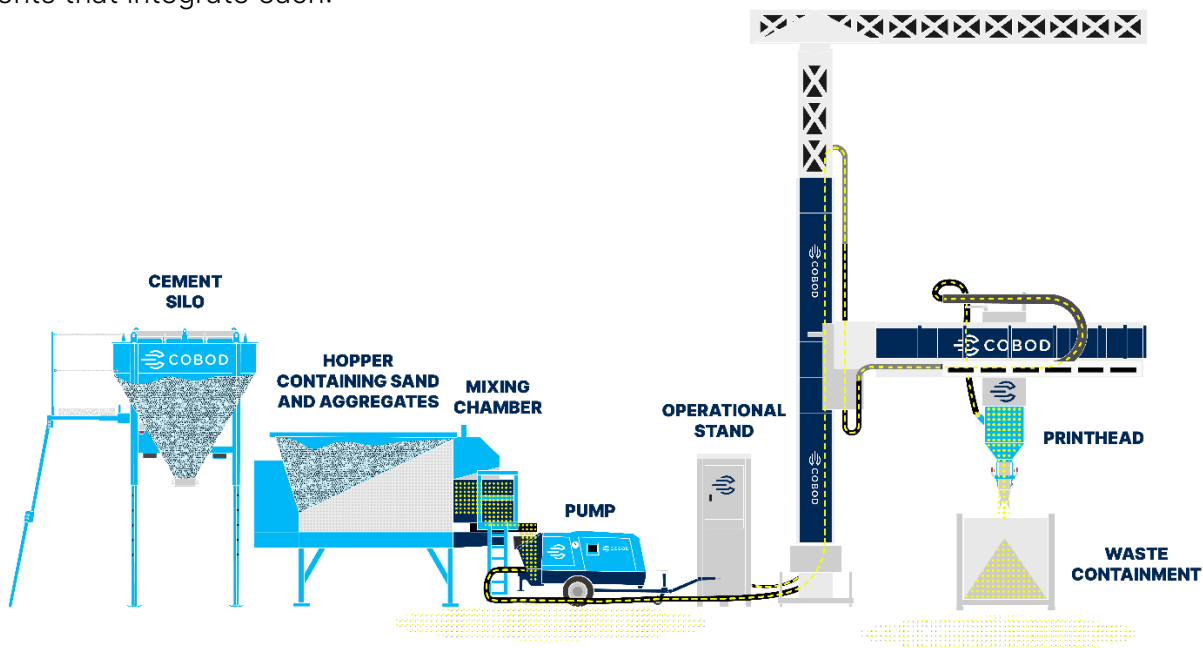
Responsibility

Printer cleaning operations fall under the printer specialist (PO) and printer specialist assistant (POA). In parallel, the Material Delivery System is the responsibility of the material specialist (MO) and his/her assistant (MOA). For experienced crews, cleaning operations take around 45 minutes, while unexperienced crews might take up to 2-3 hours for the first days until the dynamic is streamlined.

Overview

Cleaning is required for the entire 3d printing system starting from the MDS all the way to the printhead. The following chapter expands on the hose and printer while more detailed information for the pump and mixer cleaning practices can be found in their individual SOPs.

Below is a diagram showing both dry and wet material flows in the system, as well as the components that integrate each:



Dry material flow: Can be summarized to dust control practices and includes the silo and batch plant aggregate hoppers.



Wet material flow: Needs to be cleaned every day after printing operations and includes the mixer from the batch plant, the pump, the hose and the printhead components. Under extreme cold weather conditions, the dosing system needs to be drained on a daily basis to prevent frost. For further recommendations on the dosing system maintenance please refer to the *Maintenance practices* section of this document.

Tools needed

Effective cleaning requires a set of tools, physical cleaning areas and waste management practices. To start, all personnel performing cleaning operations should wear full PPE to prevent direct skin contact with the material or contaminated water as per OSHA's concrete handling requirements.

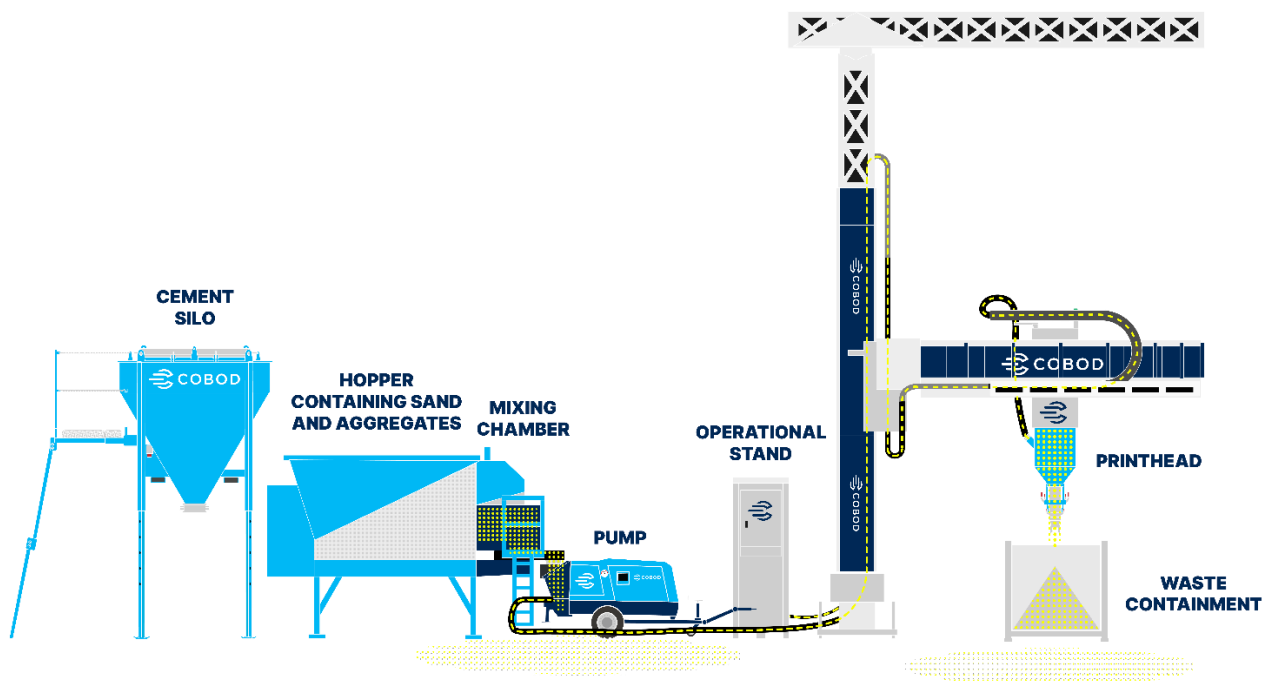
Equipment such as high-pressure washers, buckets, waste containers, steel brushes and others are further described in the *Inventory control checklists*.

Procedure

Cleaning needs to be performed relatively fast to prevent the concrete from hardening inside the equipment. As with any other concrete construction equipment, cleaning also needs to be performed effectively to prevent residue buildup which affects the machines long term.

During the sequence, the priority will always be to empty the hose, however, to do this, the pump needs to be cleaned first. Cleaning the system is a back-and-forth operation between different machines to ensure the most critical components are cleaned first due to the fact that as soon as printing stops material continues to harden inside some components, for this, cleaning operations are not a linear process.

The diagram below focuses solely in the wet material flow and shows the main areas where waste will leak to the ground. Use heavy duty plastic covers or containment trays to prevent spills reaching the soil.



BEFORE CLEANING

Waste containment

Before starting to clean, a waste containment bag or tray needs to be placed under the printhead to collect all the waste material. If you plan to dispose of it, cast it into molds or later recycle it into crushed aggregates, a specific plan should be made and communicated to the operational crew in advance.

Emptying the printhead hopper

Once the printhead is above a waste container press **"Extrude"** in Duet to remove all concrete until empty.

Disconnecting printhead hose

Proceed to disconnect the printhead hose and point it to the waste container so all waste is correctly captured.

Preparing the mixer

Before starting to clean, a water and gravel batch should be prepared for the mixer to prevent the hardening of the material inside the mixer while other more critical cleaning activities are happening. The mixer should be kept mixing with the cleaning batch water throughout the whole time.

DURING CLEANING

Pump

Start the cleaning process by reversing the pump to release the pressure from the connected hose, this can be achieved by pressing the **“reverse pump”** button.

Hose

Once the pressure has been released from the pump/hose, proceed to disconnect the following sections of the hose system:

- a) Hose-to-reducer connection.
- b) Reducer-to-elbow connection.
- c) Elbow-to-pump outlet.

Pump

Return to the pump and open the lower hatch to release all remaining concrete.

Pressure washes the inside of the pump hopper as well as the reducer and the elbow.

Once the hopper is clean, close the hatch back and fill the entire hopper with water connecting back the clean reducer and clean elbow.

Cleaning balls inside hose

Once the clean reducer and clean elbow are assembled back together is time to connect the hose. Before connecting the hose, insert two concrete cleaning sponge balls inside. These will act as scrappers pushing all left over material until the opposite end.

First system flush

With the cleaning balls inside the hose press the **“pump”** button to start flushing concrete out of the system. Concrete should start to come out on the printhead section into the waste container until you retrieve both balls.

Second system flush

Once you have collected both of the balls at the printhead, press the **“reverse pump”** button one more time, undo the hose-to-reducer connection, insert the balls again and close it back. Refill the pump hopper with water and repeat the full flushing step one more time. Flushing is performed twice every time printing is over to ensure everything is clear from material.

Pump pistons

Undo the elbow-to-pump connection and insert the pressure washer into the pump outlet, do not insert too deep, so it does not get caught up while moving the pistons. Spray each piston while you press the **“reverse pump”** button for eight cycles or until there is no more material coming out of the pistons. Cleaning the pistons is a very important step.

General pump

Pressure wash the overall pump to remove any additional concrete before closing the pump cleaning operation.

Printhead

Once the pump is cleaned, focus can switch to a different area. Bring the trolley and position it under the printhead, lower the X axis until the printhead hopper is as close as possible to the trolley. Once positioned, two people will be needed in both sides to detach manually (since the item is heavy) and turn the printer off completely.

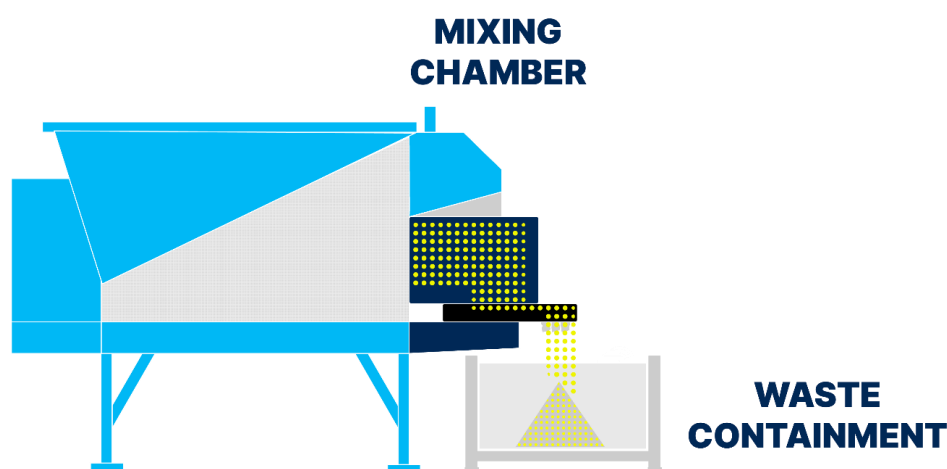
⚠ Important: Powering off and disconnecting cables from XUC (U-motor + cameras) must be done before detaching the hopper.

Detach the lower printhead – detachable segment and clean all printhead components individually on a grid with the pressure washer as seen in the image.

Emptying the mixer

Remove the pump under the mixer gate and replace it with a waste container element. Discharge the water and gravel batch that you prepared at the beginning and dispose accordingly.

After discharge, ensure to pressure wash the mixer chamber additionally through the top and bottom gates.



Dosing system

Check the dosing injectors inside the XUC-carriage lower part inside the hopper and pressure wash accordingly. If you are experiencing freezing conditions from one operational day to the other remember to drain the additive system.

AFTER CLEANING

Drainage

Water with concrete is considered contaminated and should not reach public drainage. It should be contained and disposed by a certified 3rd party or in some cases, depending on weather conditions and local code, water could also be left to evaporate. Please note, water with concrete

leaves behind concrete dust after evaporation which could slightly stain your working floor and should be vacuum when dry in a regular basis.

Waste management

This term refers to the collection, disposal and/or potential recycling of daily waste. It is important to plan these activities in advance to optimize time and site arrangements. Applicable local regulations should be always followed for disposal.

Keeping close KPIs for waste will allow you to optimize operations, save in disposal costs and taking care of the plant in the process.

Recycling

Under certain scenarios, discarded concrete can be cast directly into molds to be used as non-structural elements in the project or crushed to be reused as aggregates.

11. EXTREME WEATHER

Definition

Extreme weather conditions refer to temperatures outside the optimal printing range (10°C - 35°C).

Even if it has been proved that printing is possible in extreme cold (5°C) and extreme hot (45°C) environments, the conditions are either too close to the freezing point for overall liquids or it significantly accelerates the concrete curing processes due to heat. Both extremes could ultimately impact the people working on site, the machinery performance and the printed elements. Due to this, such conditions require additional care.

It is important to note, that extreme weather conditions are also applicable to traditional construction and are not exclusive to 3DCP. The following recommendations aim to provide general guidance on handling production in this weather, in all cases, operational teams must always comply with local regulations.

Responsibility

The printer operator (PO) is responsible for applying recommendations for the printer and dosing system, the materials operator (MO) for the materials delivery system as well as the materials stored on site. The project/site manager must ensure conditions are safe and suitable for operations.

HIGHLIGHTS

Hot weather:

- Layer time decreases in warm environments, meaning the material hardens faster.
- If aggregates/admixtures/water are also hot, the printed material will harden even faster.
- Depending on the region and labor restrictions, it might not be possible to work during heat peak hours (as with any other traditional construction works).
- Concrete that cures too fast tends to crack, for this, additional curing periodicity is recommended during and after printing.
- In extreme weather conditions, be cautious when handling electronic components that may become hot during operation and allow sufficient time for them to cool down before touching or inspecting.

Cold weather:

- Layer time increases in cold weather, meaning the material hardens slower.
- If aggregates/admixtures/water are also cold, the printed material will harden even slower and some water particles could freeze.
- In cold regions, temperature tends to drop even lower during the night so flushing liquid systems is vital after each operational day.
- Under extreme cold, the touchscreen functionality of the HMI might decrease, remote connection to IPC with a laptop is recommended.
- Depending on the region and labor restrictions, it might not be possible to work during cold peak seasons (as with any other traditional construction works).

- Concrete that hardens too slow does not support printed layers on top of it, resulting in slump and losing height. Slow concrete setting tends to have less cracks.

Humidity and Wind:

- Other factors such as: humidity levels, intensity and temperature of wind might also affect your site's operational conditions and material properties.
- Wind might carry particles that accumulate in the rails and equipment in which case further cleaning is recommended.
- Strong wind (cold or hot) can also dehydrate the printed element. If you are curing a printed part and the curing is not happening uniformly in the piece (inside and outside) the difference of the cured segment and non-cured segment will be higher under wind conditions which could increase the risk of cracking.
- For extreme humidity is important to ensure all electrical carriages lids are properly closed to prevent infiltration.

11.1 HOT CLIMATE



13. White concrete hoses

Using white concrete hoses reflects sunlight reducing heat concentration.

For more information about buying white concrete-rated hoses please contact your local sales representative or send a request to techsupport@cobod.com.



14. Covered aggregates

Covering your aggregates (on the ground or in the batch plant) with a white tarp or a heat reflective sheet can prevent them from warming up from direct sunlight exposure on site. Significantly warm aggregates affect concrete mixture.



15. Night printing

Printing during night can improve printing conditions. In locations where this is not possible, printing during the early hours of the day will provide better material results.



16. CEMII

CEMII cement is usually a better cement option for extreme heat weather due to its long setting time



17. Wind barriers

These types of protections could reduce the amount of direct wind into the printed elements preventing additional cracking due to dryness. Small perforations are needed in the surface face to prevent wind push on the panels.



18. Curing

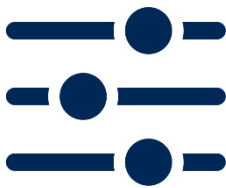
Increasing the periodicity of curing under extreme hot weather conditions is recommended to prevent cracking. Small droplet quality will ensure a humid environment without washing the cementitious paste in the layer surface finish.

For more information about buying an automated misting system please contact your local sales representative or send a request to techsupport@cobod.com.



19. Water cooler

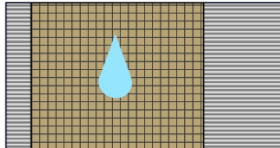
Cooling your water line or batch plant water tank is recommended to prevent hot water from accelerating the curing process in the material once the water reaches the mixer.



20. Recipe adjustments

Adjusting the plasticizer in the mix will ensure your batch continues to be fluid without affecting strength in extreme hot conditions (instead of increasing water content which consequently reduces strength).

WET BURLAP



21. Burlap covering

Using wet burlap on top of your printed element preserves moisture generating a stronger material and reduces the chance of cracks.



22. Batch plant water tank insulation

Insulating the batch plant water tank could keep water fresh for a longer period of time.



23. Mixer and pump

Covering the pump hopper and mixer with burlap and constantly irrigating it could reduce temperature under extreme heat while mixing concrete



24. Water level in batch plant tank

Keeping your water tank running at a low level in the batch plant will maintain water coming from the cooling system in low temperatures ready for use.



25. Maintenance

Extreme heat can affect normal maintenance checks, schedule additional checks prior to entering the hot season. for additional questions. Contact: techsupport@cobod.com



26. Admixtures storage

Extreme heat can affect your admixtures remember to store them at room temperature and away from direct sunlight. Flushing the additive system once the printer is not in use will also prevent clogs from material viscosity.

11.2 COLD CLIMATE



1. Tent

During winter peaks, some regions are hit by constant storms and radical temperature swings between morning and afternoon.

These temperatures usually affect working schedules for both 3DCP and traditional construction.

A solution to increase productivity could be to rent or buy a heated tent to be placed around the printer for such periods or, in smaller prints, to use wind barriers.



2. Frost in aggregates

Covering your aggregates (in the ground or in the batch plant) with a black tarp or an insulated sheet can absorb daylight and keep the elements inside protected.



3. Burst pipes

Properly flushing the batch plant tank, water pipes, admixture pipes and dosing system lines on a daily basis can prevent them from bursting during the night when temperatures usually tend to drop to freezing conditions.

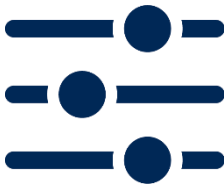
Antifreeze recommendations exist for certain components, for additional information on specific brands please contact:

techsupport@cobod.com



4. Water heater

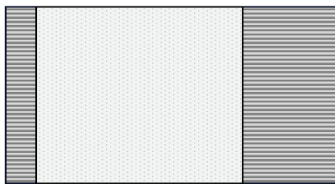
Heating your water line or batch plant water tank is recommended to prevent freezing water from delaying the chemical process during concrete production.



5. Recipe adjustments

Adjusting your mix due to extreme cold weather conditions is important. Fastly dropping temperatures and additional factors such as humidity and wind should be discussed before the start of the winter season.

INSULATED BLANKET



6. Printed element covering

Curing under extreme cold weather conditions is not recommended because the additional water film could freeze damaging the print.

However, the concrete curing process in the print does require water inside the mix to be slowly absorbed.

To insulate curing concrete from cold ambient air, methods such as using insulated blankets or heated enclosures can be employed.



7. Batch plant water tank insulation

Insulating the batch plant water tank could keep water coming from your water heater in a more workable condition for a longer period.

For more information about buying a winter package for the batch plant please contact your local sales representative or send a request to techsupport@cobod.com.



8. Water level in batch plant tank

Keeping your water tank running at a medium level in the batch plant will maintain water coming from the heating system usable a too small volume could freeze faster.



9. Maintenance

Extreme cold can affect normal maintenance checks, schedule additional checks prior to entering the cold season and prioritize daily drainage.

Furthermore, when cleaning, prevent to leave water ponds that could freeze overnight and damage certain components.

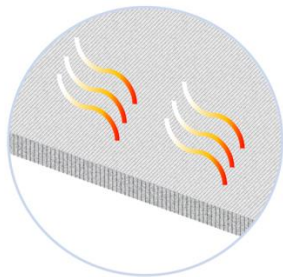
Contact techsupport@cobod.com for additional questions.



10. Admixtures storage

Extreme cold can affect your admixtures, remember to store them at room temperature away from freezing temperatures.

Flushing the additive system once the printer is not in use will also prevent clogs from frozen material.



11. Heated slab

In extreme cold weather conditions, a heated slab integrated into the project could provide additional value complementary to the heated tent.

12.PRINTER MAINTENANCE

Definition

Printer maintenance refers to the regular upkeep and servicing of a printer to ensure its optimal performance and longevity. Recommendations below are divided by periods of time such as daily, weekly and every time the printer is moved.

Having spare parts in stock and overall inventory management are also important for keeping a lean operation. Additionally, proper maintenance would ensure that the printer's software is up to date to avoid compatibility issues.

The practices recommended below apply for general operational conditions, however, when operating at maximum speed for longer periods of time and/or under extreme weather conditions, additional care practices and increased periodicity might be needed. Contact: techsupport@cobod.com to request any additional maintenance information you might need for your site-specific conditions.

Prerequisites

- BOD3 required toolkits:
- BOD3 Set up and maintenance kit
- BOD3 Customer Printing kit
- BOD3 Spare parts kit
- Materials kit
- Installed and operational printer with hose management system installed.
- Certified L2 printer operator on site.
- COBOD Site Readiness checklist completed.

Contact techsupport@cobod.com to confirm any required replacement parts if needed. If you have purchased a COBOD Spare Parts kit, please confirm with a COBOD ITS representative you have the correct part with a photo before replacement.

Responsibilities

The printer operator (PO) is responsible for performing and keeping appropriate records of all printer maintenance works as well as an updated inventory control, furthermore, maintenance records are required for any warranty claim. Maintenance should be performed on a preventive manner and less in a reactive manner.

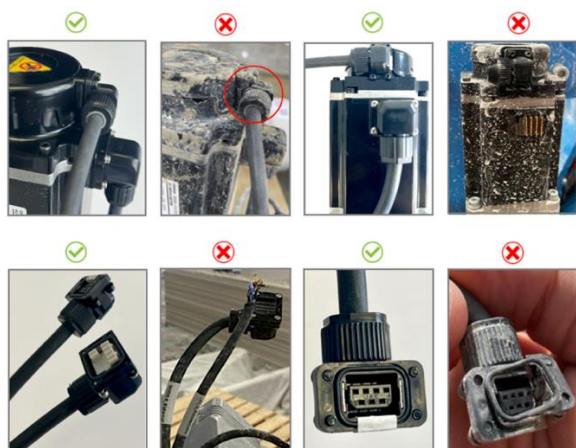
A backup plan should be created by the GC to address any potential breakdown, material supply shortage, weather impact or utility constraint such as water shortage or a non-functional power generator on site.

Best practices

- Having a maintenance schedule, historical records and clear roles and responsibilities promotes optimal equipment performance.
- Not following maintenance recommendations can lead to frequent downtime, increased equipment malfunction, poor safety performance and budget overruns.

12.1 MAINTENANCE SCHEDULE

A) DAILY MAINTENANCE PRACTICES



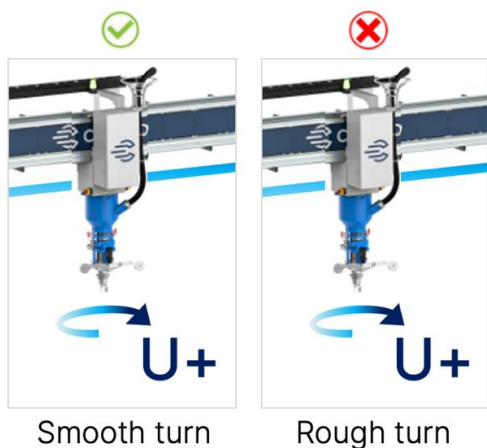
1. U-cable / U-motor connection

Visually inspect the connection between the U-cable and the U-motor for any visible damage.

Handle with care when installing and while washing the printhead, beware of accidental pulling.

Harm in this section would require replacement and is statistically the most common operational error.

The U-motor comes with a 3D printable plastic cover that protects the item significantly, in case you do not have it, you can download the file for free in COBOD Connect and print it locally.

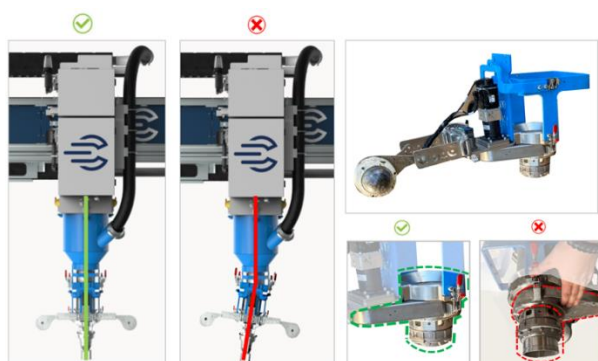


2. U-axis movement

Confirm U-axis movement by attempting to rotate the U-nozzle by hand in clockwise direction.

U-cable MUST be disconnected when performing this review.

A working U-axis should turn smoothly and easy while a notchy movement would indicate concrete dirt, wrong assembly and/or bearing issue.



3. Nozzle block alignment

Confirm the printhead assembly is fully vertical and that the lower printhead part is correctly installed.

Incorrect placement of the nozzle block part could lead to misalignment.

Verifying alignment is important to ensure repeated quality on the printed elements.

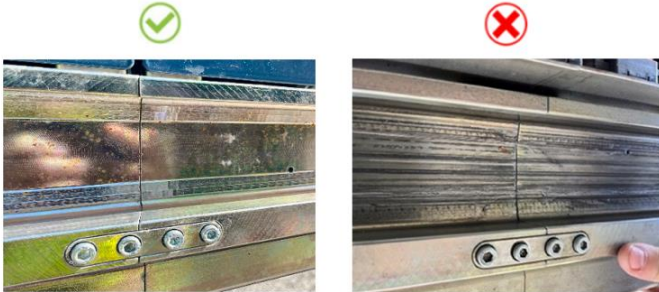
4. Bearing rails

Visually inspect bearing rails in all axes, if any noticeable debris is found, clean with high pressure washer, wet rag, or compressed air.

We do not recommend putting an excessive amount of grease since this could create a film that traps additional dirt. Dry grease is preferred.

Horizontal bearing rails (X and Y) are more prone to collect dirt than the vertical ones in Z.

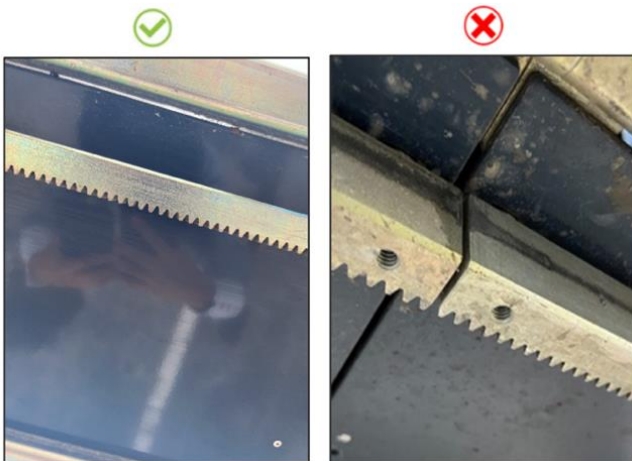
Keeping all bearing rails clean will expand bearing life.



5. Tooth racks

Visually inspect tooth racks on all axes, if any noticeable debris is found, clean with high pressure washer, wet rag, or compressed air.

Keeping all tooth racks clean will expand cam follower and cogwheel life.



6. Hopper level sensor

Carefully clean the hopper level sensor with a wet rag. The sensor has a film across the tip that can be damaged if cleaned by a pressure washer.

After cleaning, confirm its functionality by holding an object under the sensor and verifying on the *Materials* tab of the HMI that the value is changing. Beware of any potential hit while transporting.



TBD

7. Concrete pump signal

In the HMI, set the *Material tab* to “auto pump” and enable remote signals on the COBOD pump with the communications cable connected, proceed to check the pump signal by pressing the blue button on the operator’s remote or by extruding with an empty hopper.

Incorrect pump settings or a damaged cable would impact signal communication.



8. Z-levels (verticality)

Using a digital spirit level, confirm all Z-axes are within the verticality recommended range of 0.05° angular tolerance in both directions.

Unleveled Z-columns cause printer misalignment and increase bearing wear.

Incorrect ground compaction, storms, earthquakes, and abrupt machine stops can cause Z-columns to move.



9. Y and X levels (horizontality)

Place a multiline laser in the middle of the axis and confirm all Z-carriages are in the same plane.

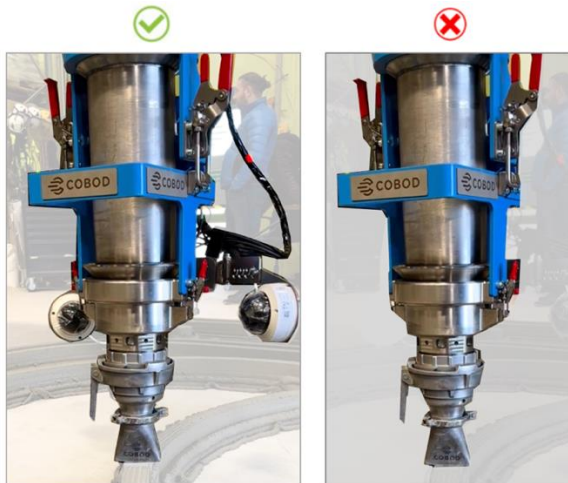
Unleveled Y and X axes will cause difficult printing alignment and potentially increase bearing wear.

Incorrect ground compaction, storms, earthquakes and abrupt machine stops can cause Y and X axes to move.

TBD

10. Y to X angle (perpendicularity)

Constantly verify perpendicularity with laser precision in all relevant angles.



11. Camera connection and angle

Log into each camera and confirm they are operational, adjust view angle using Allen keys on the mounting hardware to optimize their view.

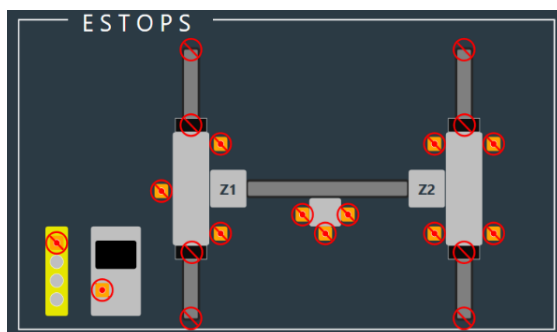
Remove for cleaning daily.



12. E-stops damage

Visually inspect all E-stops for damage. E-stops are usually damaged during transportation due to incorrect packing, rigging and/or placing lifting straps incorrectly.

Physically damaged E-stops automatically disable the printer and immediate replacement is needed.

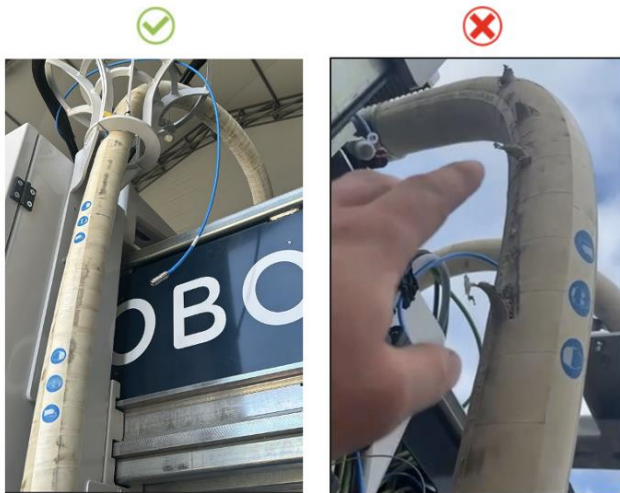


13. E-stops functionality

While the printer is in operational mode, press all E-stops individually and confirm they are shown as pressed on the Emergency Stop Map located in the *Movement* tab of the HMI.

After confirming, release each individually, and verify they are all shown as untriggered on the HMI interface.

Physical damage to an E-stop button would compromise functionality and disable the printer.



14. Concrete hoses

Visually inspect all hoses for damage and ensure all safety connection mechanisms are in place.

Safety connection mechanisms include anti-whiplash cables and clamp safety pins. Damaged hoses can burst from pressure and result in serious harm for both personnel and equipment.

Always use safety mechanisms per connection point.

Correctly identifying hose connection points is also useful for clog management during operations.

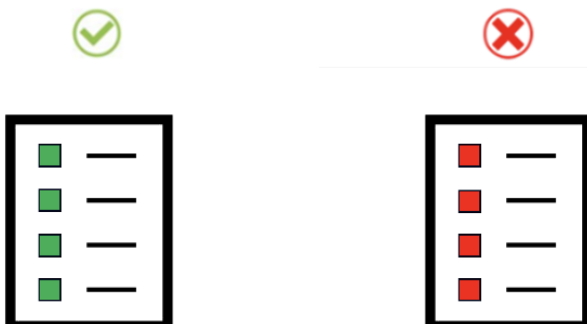


15. E-chains/C-chains

Visually confirm all parts are connected and intact.

A poor maintenance indicator for E-chains/C-chains would be to notice small black plastic fallen pieces during operations.

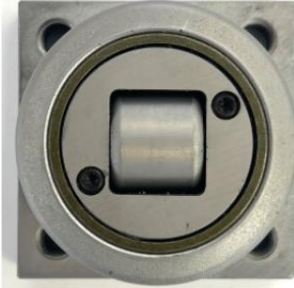
Broken E-chains/C-chains can promote the damage and fall of elements inside. When rolling E-chains consider the bending radius and beware of not pinching the cables.



16. Extreme weather

Prepare your printer and materials in accordance with the *Storage* recommendations chapter which includes scenarios with extreme weather conditions.

B) WEEKLY MAINTENANCE PRACTICES

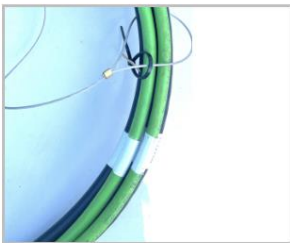


17. Grease bearings

Dismount all X and Y bearings and grease from the grease point nipple in the back.

You can spray grease on the rotation section in the outside, but it will not have the same effectiveness as the greasing point.

Greasing your bearings often will extend operational life.



18. External cables and plugs

Inspect static cables and E-chain cables for any signs of damage such as peeling, humidity, chewed, pinches or cuts (focus on areas where plugs connect since this section is more exposed).

Incorrect installation, not closing the lids and potential animal nesting can cause some of the damages mentioned above.

Damaged cables can generate signal errors, unsafe conditions and operational downtime.

Always consider cable management and lengths when installing or resizing your machine.



19. Dosing hoses

Inspect the dosing hose for leaks, cuts or pinches (they are usually located near the connection points).

Always drain if you expect freezing conditions or if you are planning to stop operations for an extended period of time.



20. Humidity indicators

Open all carriages and check silica bags, moisture bags and stickers (humidity indicators) for discoloration as well as any other signal of water presence.

If any discoloration is found, replace all bags, inspect watertight seal is not compromised and contact local COBOD ITS representative for replacements.

BOD3 System Verification			
Common Version:	Device:	IP/Name:	User:
Printer Config:	IPC:		Password:
Serial version:	Router:		
Printer version:	Dust:		
Location:	Cam 1:		
Reconnectable Pin:	Cam 2:		
(BOD3D, Initial)	Web:		
Printer model:	Web:	Low	Hi
Printer weight:	EU/US:		
Printer year:			

This document provides the steps to perform after each printer installation to verify that the installation is correct. It is not meant as a guide but should be used with the BOD3D SOP, which contains all relevant guidance on each step.

This document proves as the verification that the printer is installed on-site, and a signed copy will be shared with the customer and stored internally for reference. Any terms listed in this document as missing or faulty are the responsibility of COBOD to provide.

Use this document's installation verification to check off each point and list all issues on the SAT report on the last page.

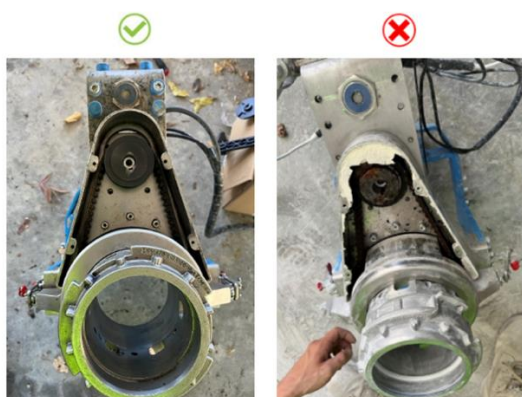
#	Phase	Description
1	Overview and Prerequisites	Overview of the processes involved for complete system checks as well as validation of machine parts and elements, prior to the system verification process.
2	Installation Verification	Printer full assembly and initial following guidelines for correct distances and Z alignment verification: Z1 to Z2, Z perpendicularity Y & X alignment using Machine laser X-Y perpendicularity verification Start and chain cable installation
3	Operational Verification	Operational verification, performance verification, system verification
4	System Verification (SAT)	SAT print using customer recipe, only customer recipe with D-fab solution *Minimum of 10 print *Consistent containing challenging segments, i.e. sharp corners along both X and Y *Minimum of 3 layers must be performed on 200-mesh and carefully observed, highest speed possible for the process and the job *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 alignment as well as during on-site installation (SAT)
5	Generate SAT Report	

21. Site Acceptance Test (SAT)

Set up the printer by following the SAT and report any issues you find to your local COBOD technician.

Not performing the SAT thoroughly might result in issues while printing.

Please follow all instructions and keep records per site to detect maintenance patterns.



22. Lower nozzle block assembly

Disassemble and clean U-belt compartment by removing the cover plate, cleaning with wet and dry cloths thoroughly, verify the belt is tight.

With regular use, material and debris might accumulate inside the compartment affecting the mobility of the belt. A loose belt will create U-axis alignment issues.

It is important to maintain this area clean and the belt tight to prevent downtime.

23.Stackers

Please note the wood stackers included in your original shipment are disposable and not for permanent use, furthermore, wood stackers are not weatherproof and will decay over time.

To keep printer elements in stable positions, it is important to replace stackers when physical damage is identified.

A digital file is available in COBOD Connect to locally produce more permanent stackers.

For additional information please refer to the *Packing Recommendations* section of this document.



24.Homing clickers

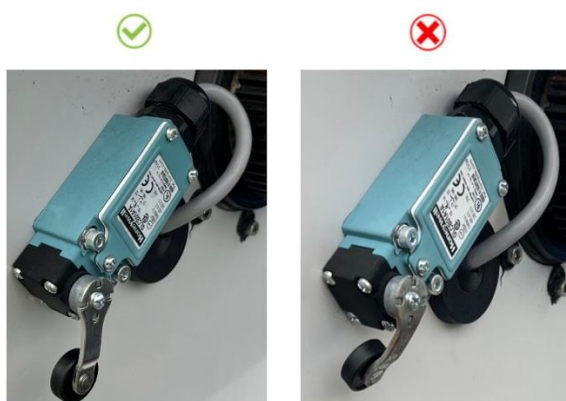
This review requires the X axis to be dis-mounted.

Visually inspect all homing clickers for damage.

Homing clickers are usually damaged during transportation and installation especially on the arm as seen in the picture.

Damaged homing clickers will affect the automatic homing of the X.

The machine also has “collision clickers” further described below and is important to distinguish the differences between both types of clickers.



TBD

25. Priming the dosing system

Pump chemical through the dosing system hose until it flows consistently out of the injector located in the hopper, if any air bubbles appear in the line keep pumping until all the air bubbles are out of the line.

Pinched hoses and/or old accumulated additives might create clogs in the system.

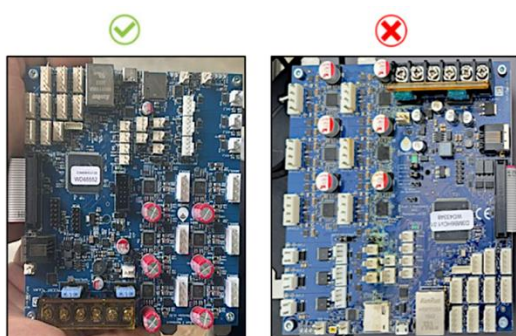
TBD

26. Purging dosing system

Empty your dosing system hose by pumping water all the way through the line before transporting the dosing system to avoid clogging in the future.

If you are in a warm weather area you can use water, if you are in a cold weather area water with anti-freeze liquid mixed in could prevent hose burst in case of freezing temperatures.

Use adequate containers such as buckets to collect waste.

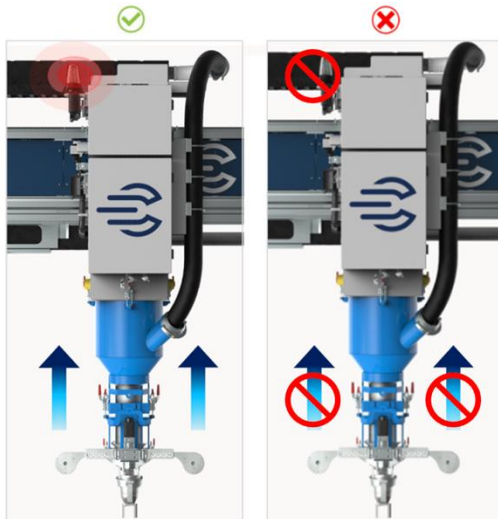


27. Duet boards

The next step can only be performed by L3 certified operators with direct guidance from your local COBOD technician.

Visually inspect the Duet main board for any signs of corrosion, damage, discoloration or signs of decay such as green rust (a common indicator of water infiltration).

Incorrect closure of the carriages hatch and/or not monitoring silica bags often would result in humidity infiltration.



28. Collision sensors functionality

The printhead has 3 sensors (1 in Y+ direction, 1 in X+ and 1 in X- direction).

This step consists in pushing the printhead in those three directions to verify clickers functionality.

Stand in front of the printhead and pull the nozzle towards you in each of the three directions, this will engage each sensor one at the time.

Correct functionality will trigger an error response and the signal lamp will turn red while the machine will slightly move up along the Z-axis, a non-working feature would not trigger any response.



29. Harting lids and plugs

Visually inspect Harting plugs and/or lids have two bolts installed correctly.

Do not use power tools to tighten the bolts. This could damage the cover and the compressive seals.

Missing or loose bolts can cause the plugs not to be connected all the way through generating inconsistent communication when operating the printer.

Loose bolts in the lids could cause moisture issues.

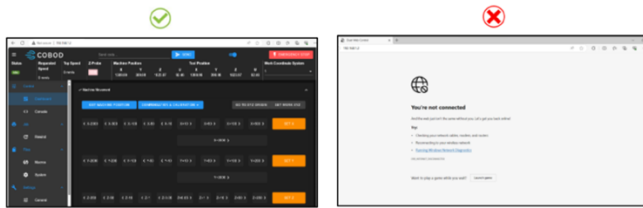


30. Components review

While disassembling, inspect the homing clickers, bearings, and other small components for any signs of degradation.

Est there are no broken items by manually rotating bearings and pushing clickers.

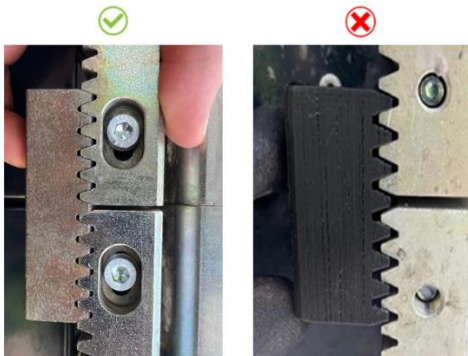
Clean off with a wet rag and grease to improve lifespan.



31. Duet connection

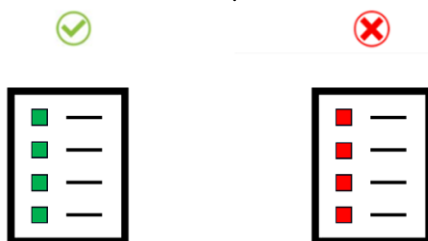
Open Duet interface via browser on your computer/laptop [192.168.1.2].

Damaged cables and/or interference with other high signal emissions close to site could affect connection between the printer and your laptop.



32. Tooth rack calibration

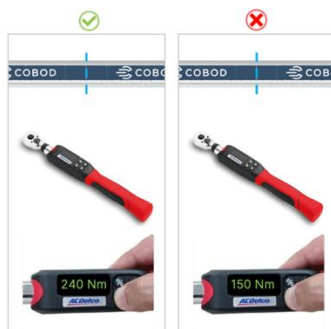
Check tooth rack alignment on every machine setup by placing the tooth rack calibration block on the junctions of all your module connections to verify alignment.



33. Inventory

As instructed during Level 1 training, use COBOD Slice volume estimation, COBOD materials guidelines, COBOD equipment inventory checklists, and consult with your local COBOD ITS representatives to confirm you have all recommended spare parts and enough chemical material to complete your projects in advance.

Keeping an organized inventory, site and maintenance records will ensure quality repeatability and increase project productivity.



34. Modules connection points

Confirm with a torque wrench that all the bolts in the connections between modules are up to a minimum of 240 Nm of torque.

Device		User	Password
IPC			
Router		Root	
DUET		----- -----	
Camera 1		Admin	
Camera 2		Admin	
Wi-Fi		----- -----	
#	Status	Comments	
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
12.			
13.			
14.			
15.			
16.			
17.			
#	Status	Comments	
1.			
2.			
3.			
4.			
5.			
#	Status	Comments	
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			

13. TROUBLESHOOTING

13.1 GENERAL CONCEPTS

Always refer to the error handling guidelines when experiencing issues on the job site. Identify the symptom of the error and proceed to follow the steps in the order they are presented in the “solution” field.

If an error occurs while printing with materials in the system, the materials operator should keep a timer on the materials. This is done to keep track of the time it is standing still in the system to avoid it hardening anywhere in the system. The timeframe should be provided by the Materials Operator. If the troubleshooting at any point extends the given timeframe and there is a risk of material clogging, stop the troubleshooting and clean the entire Materials system (hoses, print head, pump, mixer) before continuing. It is possible to extend the time available and keep the concrete alive by continuously purge material from the print head into a waste container.

 **Attention!** The first thing to check is the troubleshooter in the Soft-NA on the IPC (screen) which will give a clear indication on the issue. Together with the “node number” the user can quickly assess where the issue is and can tell that to a technician to optimize the troubleshooting. Furthermore, the troubleshooter will give a list of possible steps to resolve this as well, which can be helpful to the user and the technician.

ERROR HANDLING

The steps to solve are ordered so that the most likely solution will be the first one presented. When solving an error all steps might not be needed.

 **Attention!** Never work on electrical components with the power on as this can result in electrical shorts or shocks that could harm personnel and/or the equipment.

REBOOT SEQUENCES

Soft reboot: During a troubleshooting session a soft reboot might be necessary to remove an error, by removing the main power supply to the drivers and main 24V system. How to perform a soft reboot:

1. Turn the main power switch to off and wait for a pop-up in the HMI (Screen).
2. Click pause on the pop-up, this pauses the countdown for the whole shutdown procedure.
3. Turn the main power switch to on and Wait for the pop-up to go away.
4. Go to the troubleshooter and clear all errors.
5. If an issue persists, a hard reboot might be necessary.

Hard reboot: A full shutdown of the printer.

6. Turn the main power switch to off and wait for a pop-up in the HMI (Screen)
7. Let the timer run out and check that all lights go off.
8. Turn the main power switch to on and boot up.

Node numbers

Most error messages will be assigned a node, showing where the issue is.

Nodes:

Node 1 – Z1-main-ebox
Node 2 – Z1-main-ebox EtherCAT coupler
Node 10 – Z1 IO-module
Node 11 – Z1 Motor Driver
Node 12 – Z3 IO-module
Node 13 – Z3 Motor Driver
Node 14 – Z5 IO-module
Node 15 – Z5 Motor Driver
Node 16 – Z7 IO-module
Node 17 – Z7 Motor Driver
Node 4 – Y1 EtherCAT coupler
Node 30 – Y1 IO-module
Node 31 – Y1 Motor Driver
Node 32 – Y2 IO-module
Node 33 – Y2 Motor Driver
Node 34 – Z2 IO-module
Node 35 – Z2 Motor Driver
Node 36 – Z4 IO-module
Node 37 – Z4 Motor Driver
Node 38 – Z6 IO-module
Node 39 – Z6 Motor Driver
Node 40 – Z8 IO-module
Node 41 – Z8 Motor Driver
Node 50 – X1 IO-module (Printhead)
Node 51 – X1 U-Axis Motor Driver
Node 52 – X1 X-Axis Motor Driver
Node 53 – X1 E-Axis Motor Driver

13.2 COMMON ERRORS

13.2.1 THE SIGNAL LAMP IS NOT ON	
Issue:	Printer signal lamp light is not on.
Description:	The printer has not been initiated.
Steps to resolve: 1. Plug in the operator module and turn on the printer. 2. Insert and turn the key on the operator module.	

13.2.2 TROUBLESHOOTER: DISCREPANCY ERROR	
Issue:	Printer signal lamp lights red. The printer does not respond to movement commands.
Description:	The system is either in an error state or not activated/turned on properly.
Steps to resolve: 3. Check E-stops – Go to the Main E-box and observe the screen for any E-stops triggered. Remember to check the E-stop on the Operator Panel. A triggered E-stop will show with this symbol:  Release any triggered E-stops. All E-stops have two cables that carry the same signal. Discrepancy error happens when the signal switch state not at the same time, and sometimes when an E-stop is triggered slowly. First remedy should be to quickly trigger and then un-trigger the E-stop in question. 4. With “Start” button (green button on Pilz remote).	

13.2.3 TROUBLESHOOTER: SLAVE NODE ADDRESSES DUPLICATED	
Issue:	Printer signal lamp does not light up. The printer does not respond to movement commands. The printer initiation key does not activate the system.
Description:	Some nodes in the printer are duplicated.
Steps to resolve: Contact COBOD/Distributor tech support to ensure that the node numbering is correct.	

13.2.4 SIGNAL LAMP RED – TROUBLESHOOTER: FSOE SLAVE ADDRESS ERROR	
Issue:	Signal lamp red – troubleshooter: FSoE Slave address error
Description:	The safety system is not validated and needs to be validated.
Steps to resolve: Contact COBOD/Distributor tech support to validate the safety system.	

13.2.5 TROUBLESHOOTER: SLAVE APPLICATION ERROR

Issue:	Printer signal lamp does not light up. The printer does not respond to movement commands. The printer initiation key does not activate the system.
Description:	The PLC system does not recognize the setup of the printer or the "slave nodes" are not configured correctly.

Steps to resolve:

1. Make sure that the installation of the printer is correct and make sure that the wiring of the printer is correct and that all plugs have been inserted firmly. (The U-axis is an exception).
2. Make sure that no ethernet cables are damaged, (Green cables in the echains or loose cables).
3. Contact COBOD/Distributor tech support to ensure that the node numbering is correct.

13.2.6 MATERIAL HOPPER RUNNING OUT OF MATERIAL

Issue:	Material hopper running out of material, but the signal lamp is solid green, and the pump is not pumping material.
Description:	Printer is not outputting pump signal.

Steps to resolve:

1. Go to the "Materials" tab on the HMI and check if your level setting is set too low. Readjust level settings.
2. Go to the "Materials" tab on the HMI and if it indicates that the hopper is full then safely clean the level sensor on the printhead.
3. If needed, make sure E is homed while Extruder is positioned directly under hopper level sensor.

13.2.7 TROUBLESHOOTER: MOTION CONTROL - AXIS 18

Issue:	The printer is unable to turn the U-axis.
Description:	The U-axis cable is not connected.

Steps to resolve:

1. Move the printer up and attach the printhead mechanically.
2. Turn the main power switch to off and connect the U-axis motor.
3. Reset all errors in the troubleshooter.

13.2.8 TROUBLESHOOTER: ENCODER COMMUNICATIONS DISCONNECTION ERROR

Issue:	The light is green, but the troubleshooter is stating a "Encoder Communications Disconnection Error"
Description:	A motor with an encoder has been disconnected. This is very common if the printhead is not attached and the system can move around (except the U-axis).

Steps to resolve:

1. Move the printer up and attach the printhead mechanically.
2. Turn the main power switch to off and connect the U-axis motor.
3. Reset all errors in the troubleshooter.

13.3 LESS COMMON ERRORS

13.3.1 PRINTER STOPS AND DROPS 5-10MM	
Issue:	Printer stops and drops 5-10mm.
Description:	An emergency stop has been triggered while the printer is doing a Z-movement.
Steps to resolve: 1. Identify the reason that an emergency stop was triggered. Fix and restart the printer. 2. As positioning will be wrong use the "Realign Z" and "Realign Y" on the HMI to restore accurate positioning.	

13.3.2 EMERGENCY/COLLISION DETECTION DOES NOT WORK	
Issue:	The safety system does not engage.
Description:	The safety override has been activated.
Steps to resolve: 1. Insert and turn the safety-override key to the left position. 2. Pull out the safety-override key.	

13.3.3 THE U-AXIS STOPS TURNING	
Issue:	The U-axis stops working suddenly. Troubleshooter stating motor overload
Description:	The U-axis motor has either stalled or got disconnected.
Steps to resolve: 1. Check the troubleshooter to see if the motor has stalled. 2. Check if it is possible to move the U-axis by hand. 3. If the U-axis is tight when rotating or the troubleshooter is indicating a motor stall. Check the mechanical assembly for concrete and rusted parts. 4. If the U-axis moves freely, reset the error, and move the U-axis through the PLC. 5. If the issue persists, do a "soft reboot" and reset errors in the troubleshooter. 6. Contact COBOD/Distributor tech support for further assistance.	

13.3.4 TROUBLESHOOTER: OVERLOAD ERROR	
Issue:	The motor has stalled, and the signal lamp turns red.
Description:	The motor has overloaded due to too much resistance.
Steps to resolve: 1. Set the printer to "PLC mode" in SoftNA. 2. Reset all errors in the troubleshooter.	

13.4 RARE ERRORS

13.4.1 SIGNAL LAMP RED – TROUBLESHOOTER: ETHERCAT FRAME NOT RECEIVED	
Issue:	Printer signal lamp lights red. The printer does not turn on high power.
Description:	There is a fault on the EtherCAT and/or a EtherCAT cable has been damaged.
Steps to resolve: 1. Isolate the damaged cable or plug. 2. Repair the damaged plug or cable according to specifications of a technician.	

13.4.2 PUMP IS TURNING ON, THEN REVERSING	
Issue:	The pump is turning on and then suddenly reversing.
Description:	There is a bad connection in your pump remote.
Steps to resolve: 1. Disconnect the pump remote and check the inside. 2. If there has been some water sneaking in, dry it out, and reseal it.	

13.4.3 TROUBLESHOOTER: MOTOR REPLACEMENT DETECTED	
Issue:	The troubleshooter is stating “Motor Replacement Detected”.
Description:	A motor has been replaced and needs to be verified in the PLC system.
Steps to resolve: Contact COBOD/Distributor tech support to reset the motor errors.	

13.5.3 TROUBLESHOOTER: BRAKE INTERLOCK ERROR	
Issue:	The printer moves up/down on the Z-axis and when stopping, the printer goes into error mode and the signal lamp turns red. Related to this error message: “Power Module error”
Description:	The printer has a bad connection to one of the braking resistors on for the motor a Z-carriage. Sudden stop of Z carriages motors due to failing braking system.
Steps to resolve: 1. If possible, move the printer up, until there is room to work inside the Z-carriages. 2. Open the Z-carriage that has the issue. (Check the Node number). If in doubt, go through all of them. 3. Turn the main power switch to off and check the wires going from the braking resistor to the driver. If in doubt, contact COBOD/Distributor tech support for further assistance.	

14. ADDITIONAL FEATURES

Additional features contain information regarding features which are not vital for the installation or operation of the BOD3 3D printer. However, they are features that can be implemented in certain situations to ease and expand the overall 3D concrete printing experience.

14.1 HEIGHT MAPPING

Height mapping is used to compensate for an uneven surface and level the printed structure. The height mapping is a function originating from plastic 3D printing and utilized for 3D construction printing. The surface leveling will happen over 500mm-1000mm according to settings and layer height. A rule of thumb for this is the bigger the layer height is, the smaller the surface compensation you will need. Example: 40mm layers, with a 20mm height deviation, a compensation height could be 560mm so according to the layer height, the printed structure is level after 14 layers. The function is most applicable if the surface has a slope or if the surface is very bumpy.

⚠ Attention! This function works best when you have a square area and define only the area that is needed for the print as probing a big area takes time and the process cannot be interrupted.

This function would not be needed if the height deviation is less than 10mm with a 40mm layer height or 5mm with a 20mm layer height as the height compensation can be adjusted to the highest point on the surface.

How it works:

The surface-compensation works by probing the surface with the “Z-probe” which is located next to the printhead. The probing of the surface will be executed in a grid with a distance 500mm-1000mm between the probe points. After the probing has been finalized a height map will be saved according to the way you have chosen to save it and can be pulled up before doing a print.

⚠ Attention! If the printer is moved or the whole area is not mapped the height map will need to be performed again. It is advice to print on a level surface.

How to perform height-mapping:

- Test and calibrate Z-probe to ensure that the probe will measure correctly.
- Use the Z-probe to calibrate the printer’s Z-height precisely to the ground.
- Read and understand the entire process before attempting to calibrate the Z-probe.

Setup of Z-probe:

⚠ Attention! Before attempting to use the Z-probe, manually move the printhead towards the ground in small steps and make sure the Z-probe value in the web interface changes to 1000 before the nozzle touches the ground. Preferably there is still 10cm buffer between the tip of the nozzle and the ground when the value switches.

A) Calibrating the Z trigger height

1. Find a relatively levelled surface that spans from the most frontal part of the nozzle to behind the end of the Printhead. Make sure it is even with the rest of the printing area. Use a spirit level to ensure the surface evenness.
2. Disable the axis limits by sending “M564 S0”.

3. THIS WILL ALLOW THE PRINTER TO MOVE OUTSIDE THE DEFINED PRINTER VOLUME. DO NOT MOVE IN LARGE STEPS. USE WITH CAUTION.
4. Move the nozzle towards the ground in small steps until the nozzle is about 1mm from the ground. Manually set this position as Z0 by sending "G92 Z0".
5. Enable the axis limits by sending "M564 S1".
6. Move the Printhead manually upwards until the Z probe value in the COBOD (DUET) Web interface reads "1000".
Note: If this is not displayed on the web interface, please contact COBOD Tech-support.
7. Move 100mm further up.
8. Start a Z-probing move by sending "G30 S-1". This will move the printhead towards the ground and stop moving when the Z-probe is triggered. Write down the reported Z height.
9. Repeat from step 6 two or three times and calculate the average reported Z height.
10. Save the measured Z trigger height to the G31 command in the "config.g" file: Example > G31 X0 Y200 ZNNN

B) Using the Z Probe

- Z-probe at the current position
- G30
- Z-probe at a specific location
- G30 X NN Y NN

C) Setup of the complete bed compensation

1. Find the minimum and maximum X and Y coordinates of the area to be measured and subtract 200mm from the maximum Y coordinate.
2. Decide the probing interval. We recommend values between 500mm and 1000mm.
3. Set the calibration are with M557 X MIN: MAX Y MIN: MAX S INTERVALL
4. Alternative set the calibration with M557 X MIN: MAX Y MIN: MAX PXX: YY (where XX: YY represents the total number of reference points in each axis)
5. The M376 H NN command is used to taper off bed compensation over a specified height. We recommend an H value of 500.

D) Use the complete bed compensation

⚠ Attention! The printer must be homed in all axes before using the bed compensation.

Example:

1. **Probe** the bed in the area defined by M557, save height map to "heightmap.csv" (default) and enable mesh bed compensation.
G29 S0
2. **Save** the current height map file (visible in the "system files" tab, giving the file a name)
G29 S3 P"FILENAME.csv"
3. **Disable** mesh bed compensation (Disable height map).
G29 S2
4. **Load** height map file "FILENAME.csv" and enable mesh bed compensation
G29 S1 P"usual.csv" ;
S0 Probe the bed, save the height map in a file on the SD card, and activate mesh bed compensation. The height map is stored in file is /sys/heightmap.csv.
S1 Load the height map from file and activate mesh bed compensation. The default filename is as for S0 but a different filename can be specified using the P parameter.
S2 Disable mesh bed compensation
S3 Save height map (supported in RepRapFirmware 2.04 and later)

P"file.csv" Optional file name for height map file to save with S3 or load with S1.

If G29 is commanded with no S parameter, then file sys/mesh.g is run if it exists, and in RRF 3.3 and later any parameters present are passed to mesh.g. If sys/mesh.g is not present then the command behaves like G29 S0.

15. RELATED DOCUMENTATION

In addition to this SOP, the following documents should be consulted:

- L1-L2: Training overview.
- SRC: Site Readiness Checklist.
- SAT: Site Acceptance Test.

Recommended Tool Kits:

- BOD3 Setup and Maintenance Kit (can be purchased from COBOD).
- BOD3 Printing Kit (can be purchased from COBOD).
- BOD3 Spare parts Kit (can be purchased from COBOD).
- Materials Kit (COBOD can provide guidance).

Other Standard Operational Procedures:

- SOP: Modelling and Slicing
- SOP: Batch Plant
- SOP: M-tec
- SOP: Concrete Pumping System
- SOP: COBOD's guide to D.fab

For any technical questions related with your equipment please contact:
techsupport@cobod.com

Thank you

We appreciate the trust and confidence you placed in COBOD through the purchase of this printer. We strive to continually create quality products designed to enhance your construction experience.

Visit our website www.cobod.com to see our full line of product solutions available for your construction needs.

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**FOLLOW US****STANDARD OPERATING PROCEDURE: BOD3**