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SPOCC User Manual
Rev. 1.0

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List of Acronyms

OPSys	Optical Payload System
SPOCC	Space Optics Calibration Chamber

Revision Log

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Abstract

This User Manual collects all the procedures related to the operations performed on the Space Optical Calibration Chamber (SPOCC) hosted in the Optical Payload System Facility (OPSys).

1. Introduction

The Space Optical Calibration Chamber (SPOCC), property of INAF–OATo, is the optical test and calibration vacuum chamber housed in the Optical Payload System facility (OPSys) at the Aerospace Logistics Technology Engineering Company (ALTEC SpA) in Turin, Italy.
SPOCC is specially tailored to perform tests on solar instruments like coronagraphs [1]. The only other facility specialized for testing coronagraph instruments in the “Solar Coronagraphic Optical Test Chamber” (SCOTCH) at the US Naval Research Laboratory, Washington, DC USA [2].

This User Manual reports all the specific procedures related to the following operations to be performed on the SPOCC by INAF–OATo personnel:

- Vacuum subsystem control and operations
- Handling of SPOCC cover for the opening and closure of the Calibration Chamber
- Positioning of Payload inside SPOCC
- Operation of the Motorized Optical Bench

2. Vacuum Subsystem Nominal Operations

This section describes the SPOCC pumping and venting procedures.

Notice that the manual procedure is the nominal one that shall be adopted because:

- at the auto pumping cycle starting, both scroll and turbo pumps are switched on together and sometime it has been experienced failure of one or two turbo to reach the normal working regime;
- the venting is done through V1 and V4 valves, located in the ISO 8 room, therefore admitting into the chamber air with a cleaning rate non compatible with more stringent standards.

In the following figures the vacuum system overall schematic is reported in order to provide better understanding of the test procedure execution.

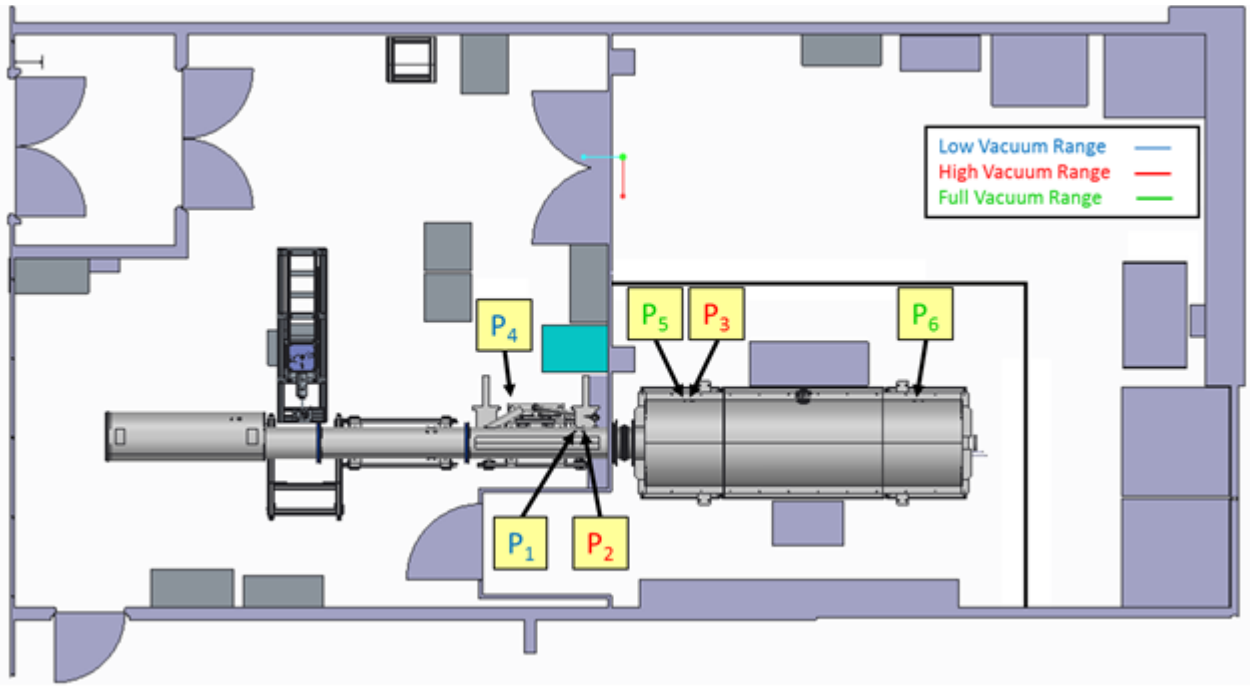


Figure 1: Vacuum gauges position scheme

Figure 2 shows the synoptic screen of the SPOCC pumping system, which displays in real time the state of the system. As it will be described in section b, it is possible to control directly the system using the manual configuration.

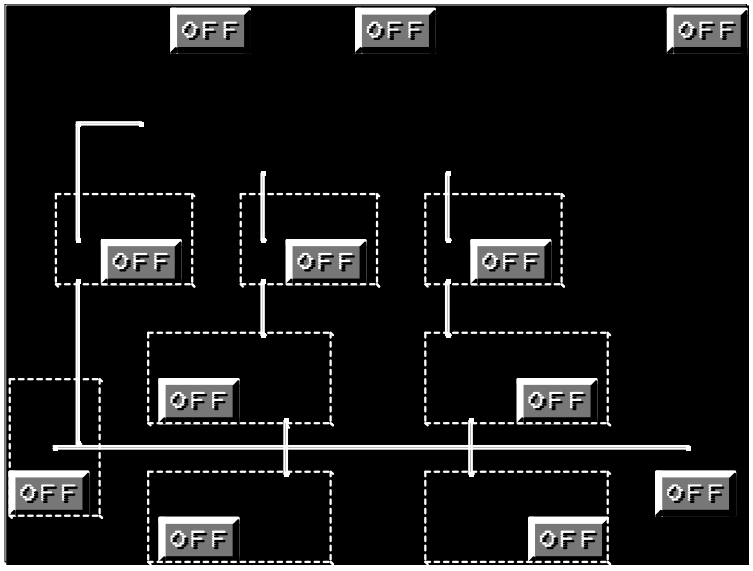


Figure 2: Synoptic screen

where:

P1	Low vacuum gauge	CONVECTORR
P4	Low vacuum gauge	CONVECTORR
P2	High vacuum gauge	IMG 100
P3	High vacuum gauge	IMG 100
P5	Full Range	PKR 251
P6	Full Range	FRG-700
V1	Elector-pneumatic valve	DN63 L7282322
V2	Electro-pneumatic valve	DN250 VGA250IE220P
V3	Electro-pneumatic valve	DN250 VGA250IE220P
V4	Electro-pneumatic valve	DN63 L7282322
T1	Turbo pump	V 3KT 9698865
T2	Turbo pump	TV1001 NAV 9698841
S1	Scroll pump	PTS03001UVPIEU
S2	Scroll pump	PTS03001UVPIEU

Table 1: Legend of the synoptic screen

Please note that the manual function is password protected, so it shall be used only by trained and authorized personnel.

a. Automatic SPOCC pumping procedure

The vacuum control system of SPOCC chamber has integrated on its control unit an automatic procedure for pumping and venting the chamber itself accessible from "**cicli**" page of interface screen (Figure 3). From this screen it is possible to access all other screens and functions. At the bottom, alarms and messages are displayed.

Figure 3: Interface screen of vacuum subsystem

Figure 4 shows the screen used to select and launch the automatic pumping cycle or to start the auto-vent procedure (return air).

These procedures are described respectively in Table 2 and Table 3.

Figure 4: Start of automatic pumping cycle and venting procedure

AUTOMATIC CYCLE	
Step No.	**Operation Description**
10	Initial state: all valves closed.
20	Open V1, V2, V3.
30	Turn ON S1; S2.
40	After the consensus of P1 and P2, close V1 and turn ON T1, T2.

Table 2: Automatic cycle procedure

VENTING CYCLE	
Step No.	**Operation Description**
10	Close V2, V3.

VENTING CYCLE	
Step No.	**Operation Description**
20	Turn OFF T1, T2, S1, and S2.

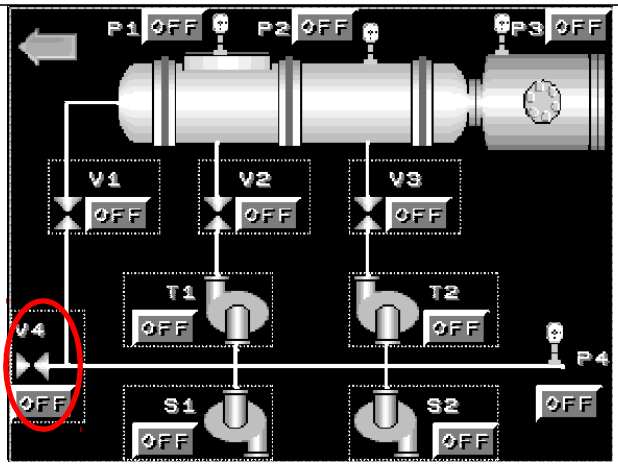
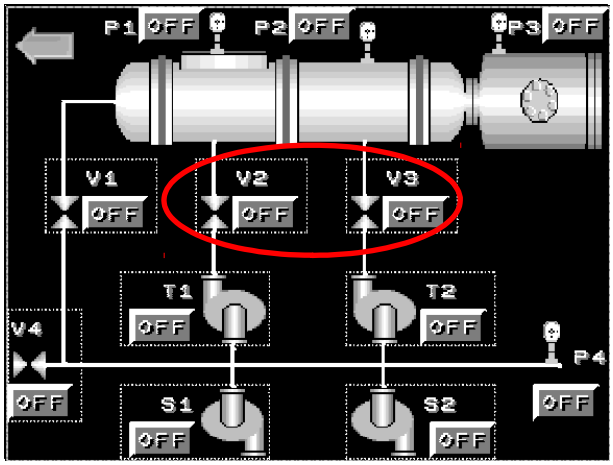
Table 3: Venting cycle procedure

Notice that before restoring the automatic cycle, you must wait the stop of turbo pumps.

b. Manual SPOCC pumping procedure

The Manual SPOCC pumping procedure is listed below.

Step No	Operation Description	Required Value
10	Set the interface screen in the manual control configuration 	
20	Insert the required access password	
30	Verify if the SPOCC is at the atmospheric pressure by reading the pressure measured by **P1**	$1*10^3$ mbar
40	Check for proper vacuum tight closure of the chamber cover and of all auxiliary ports: • Visual check for the main cover • Manual check the KF clamps	Closed
50	Verify on the screen panel that valve **V4** is closed.	OFF

		
60	If valve **V4** is open (ON) click on the screen to close it	OFF
70	Verify on the screen panel that valves **V2** and **V3** are closed 	OFF
80	If **V2** and **V3** are open (ON) click on their images on the screen to close them	OFF
90	Check if the valve of the cooling system of the turbo pumps installed on pump **T2** is closed	
100	Open valve **V1**: click on its label on the screen	ON
110	Turn on the scroll pump **S1:** click on its label on the screen	ON
120	Turn on the scroll pump **S2:** click on its label on the screen	ON
130	Wait until **P1** measures a pressure of about 4/6 mbar (1h)	6 mbar
140	Close valve **V1** : click on its label on the screen	OFF
150	Open gate valve **V2** : click on its label on the screen	ON
160	Turn on **T1** : click on its label on the screen	ON
170	Verify that the **T1** is working by watching the led on the pump	Green light

180	Wait until **T1** reaches the full speed	Green light fixed
190	Open gate valve **V3** : click on its label on the screen	ON
200	Turn on **T2** : click on its label on the screen	ON
210	Open the valve of the cooling system of the turbo pumps installed on pump **T2**	
220	Wait until **P5** measures a pressure within the chamber of about $5*10^{-4}$ mbar	$5*10^{-4}$ mbar
230	Turn on **P2**: click on its label on the screen	ON
240	Turn on **P3**: click on its label on the screen	ON

Table 4: Manual pumping procedure

c. Switch the SPOCC's pumping system off leaving the SPOCC chamber in vacuum

Before stating the switching off procedure the operator should verify that the SPOCC configuration is as follows:

1. All the four pumps, i.e. the two scroll and the two turbo pumps should be on
2. The gate valves V2 and V3 open (on)
3. The valves V1 and V4 closed (off)
4. The compressed air supply, either from the small air compressor or from an external source should be active, and the pressure gauge on valve V3 should indicate 6 bar steadily
5. Depending of the vacuum level in the chamber, the vacuum gauges directly connected to the system should be on and measuring accordingly the vacuum level: only P1 and P4 in case of low vacuum; P2 and P3 also on and measuring in case of medium-high vacuum (down 10^{-4} mbar)
6. Possibly some more vacuum gauges could be connected to the system, these are full range gauges and should be measuring accordingly
7. No action however is required with gauges P1-P4, P2 and P3 turn automatically off in vacuum raise exceeding their range
8. The RGA could also be connected to the chamber, if used for some contamination check it is mandatory to turn it off, as it will be damaged if vacuum goes higher than 10^{-4} mbar

To turn manually the pumping system of do as follows:

9. Check the pressure gauge on gate valve V3 to be sure compressed air flux is available (it should be, if not the valve cannot be operated)
10. Close valves V2 and V3 using the touch screen buttons (it change status to off when done)
11. With the buttons on the same touch screen turn the turbo pumps T1 and T2 off
12. Finally turn off the two scroll pumps
13. Check the small manual yellow valve with the green handle on turbo pump T2: it is connected in series to the venting valve of the turbo: it should be open to ensure correct venting for both turbo pumps
14. Turn off the extra vacuum gauges (P5 – P6) if present and it is not required to monitor the vacuum inside the SPOCC
15. If no more operations are foresee in short time, the compressed air supply can be closed (either turning the small compressor off or closing the valve on the pipe).

d. SPOCC venting procedure

The venting of the chamber is now done using pure nitrogen to prevent contamination of the SPOCC. A connection with nitrogen cylinder is provided on one of the KF port of the pipeline, where a Swagelok interface in mounted with a precision controlling valve. The SPOCC venting procedure is listed below.

Step No	Operation Description	Required Value
10	Verify on the screen that valves **V1**, **V2**, **V3** and **V4** are closed	OFF
20	Verify on the screen that pumps **T1**, **T2**, **S1** and **S2** are turned off	OFF
30	Open the main valve of the nitrogen cylinder	
40	Adjust the pressure gauge for an exit pressure of 0.3 – 0.4 bar	0.3 – 0.4 bar
50	Open the valve (black handle) of nitrogen meter on the line	
60	Open the auxiliary brass Swagelok valve for venting the line and final exit pressure adjustment	
70	Adjust the valve on nitrogen meter to have a flux of 1200 – 1400 l/h	1200 – 1400 l/h
80	Close the auxiliary Swagelok valve	
90	Open the precision valve (green handle)	
100	If needed adjust the pressure gauge to maintain a sustained flux	
110	Wait about 3-4 hours	
120	Check the level of pressure by closing the nitrogen flux and **carefully** opening the auxiliary Swagelok valve	

Table 5: Manual venting procedure

It is not very easy to recognize when the internal chamber pressure is equal to external atmospheric, some indications come from vacuometer P1 but the displayed pressure value is not very accurate when the internal pressure approach the atmospheric one.

A more sensitive feeling can be reached closing the nitrogen flux and opening with care the auxiliary Swagelok valve: from the gas flow direction the pressure difference can be appreciated.

3. SPOCC Cover Handling Procedures

a. Handling of the cover

All the activities related to the SPOCC cover handling shall be carried out only by authorized and trained personnel.

These activities consist of:

- Opening the cover;
- Lifting the cover from the SPOCC;
- Positioning the cover on trucks;
- Lifting the cover from the carriages;
- Laying down the cover on the SPOCC;
- Close the cover.

These activities shall be carried out by a team composed of three operators.

Personnel shall be equipped with the suitable security equipment (e.g. gloves, safety helmet and shoes).

Cover lifting, laying down and closing activities shall be executed with the following personnel configuration:

- One operator assigned to the lifting device, the team leader;
- Two operators carrying out the support activities.

The team leader shall be the same from the beginning to the end of the performed activity and shall control the other two operators when the cover is setting down on the chamber.

The following general rules shall be respected:

- During laying down activity of the cover nobody, except the team leader, is allowed to stay near the chamber.
- When the cover is attached to the lifting device and suspended nobody is allowed to stand near or pass under, completely or partially, the cover.
- It is forbidden to carry out any operation on the optical bench when the cover is not placed on the chamber or on its trucks.
- The cover handling activities are characterized by a high hazard. Personnel in charged shall be careful in order to avoid a cover crash on their finger. It is possible to avoid this risk partially by using the nylon spacers.
- The SPOCC cover can be lifted on only when the chamber is at ambient pressure.
- The lifting device shall be used in order to perform lifting activities of the cover. The machine arm shall be keep fixed on the first hole, in order to minimize its length.

b. Lifting of the cover

This section describes step-by-step the proper procedure that the personnel must follow in order to perform the cover lifting activity.

1. Unscrew all the fixing bolts between the cover and the base of the chamber.
2. Squeeze the folding part which connects the cover to the rest of the chamber and remove the bolts.
3. Hook the cover with the lifting device using the upper central hole.
4. Verify that all the bolts have been removed.
5. Lift up the cover using the lever.
6. Bring the cover to the suitable height and stop.

Refer to the related schemes in Figure 5 (SHEET 1) and Figure 6 (SHEET 2).

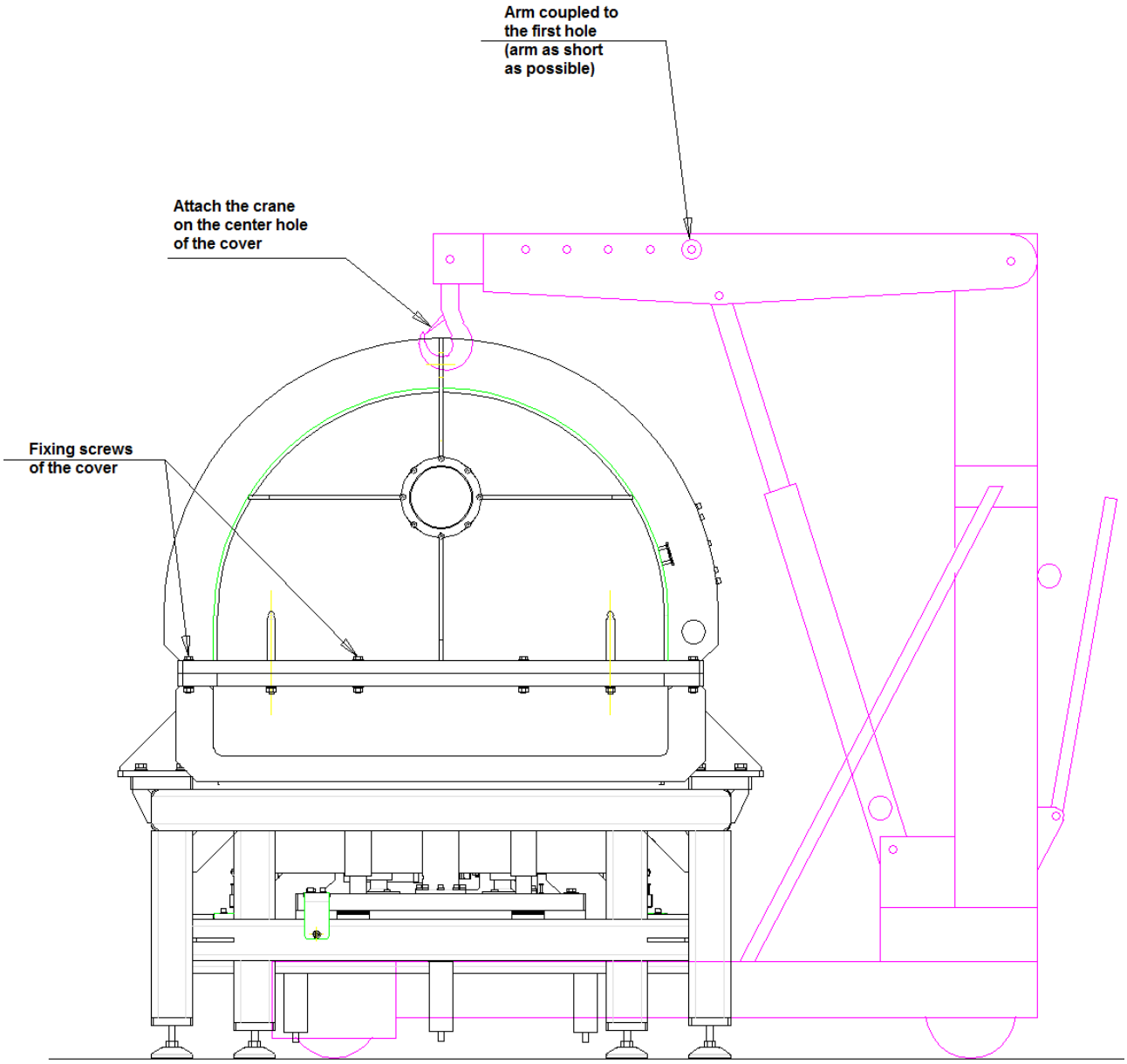
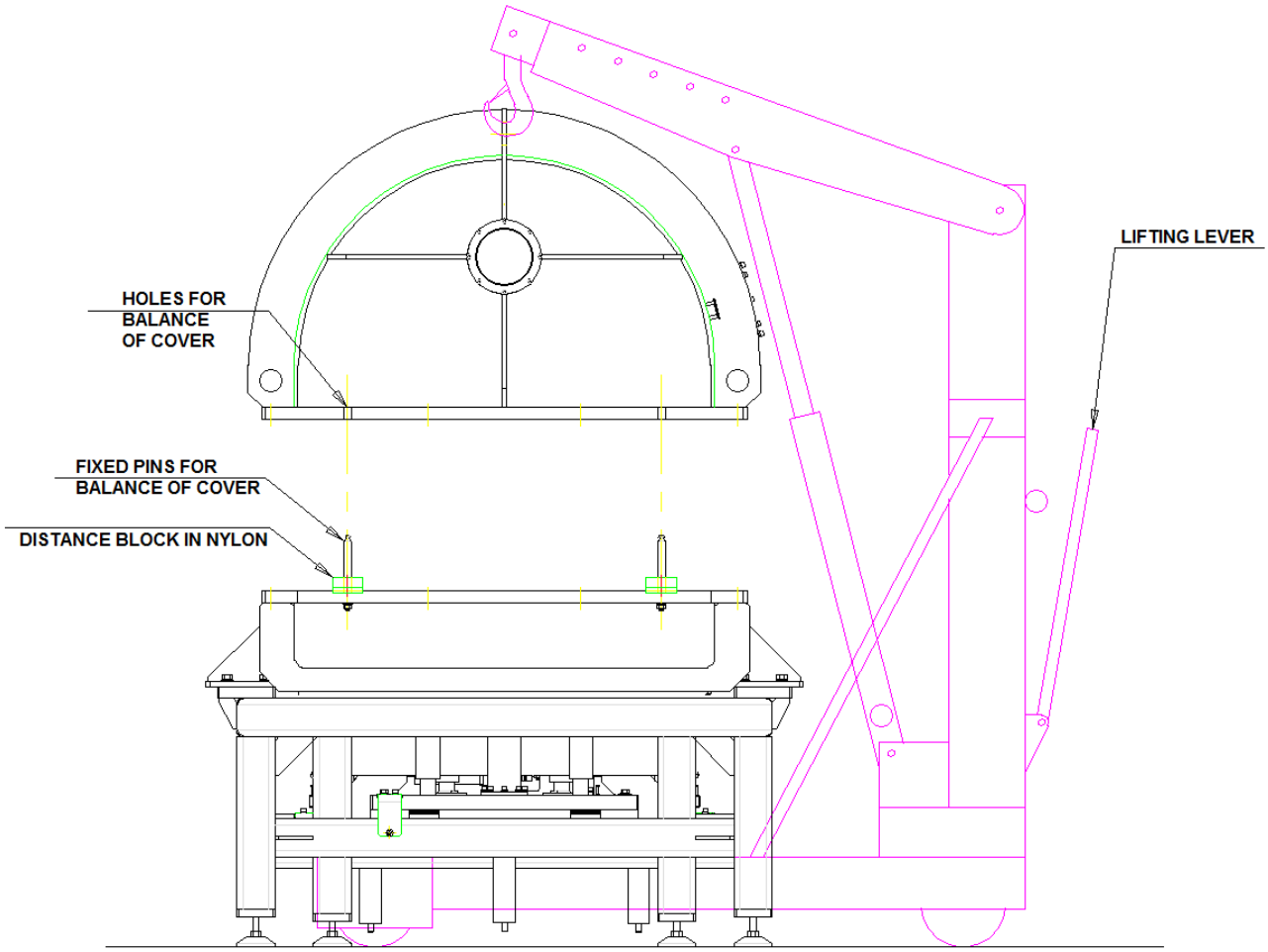


Figure 5: SPOCC cover handling procedure – SHEET 1



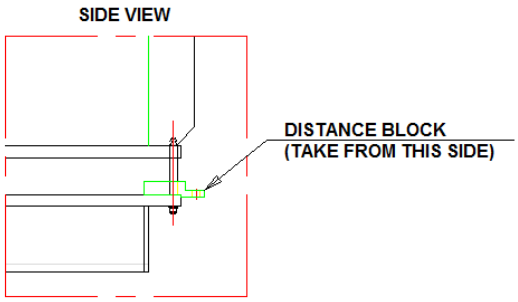


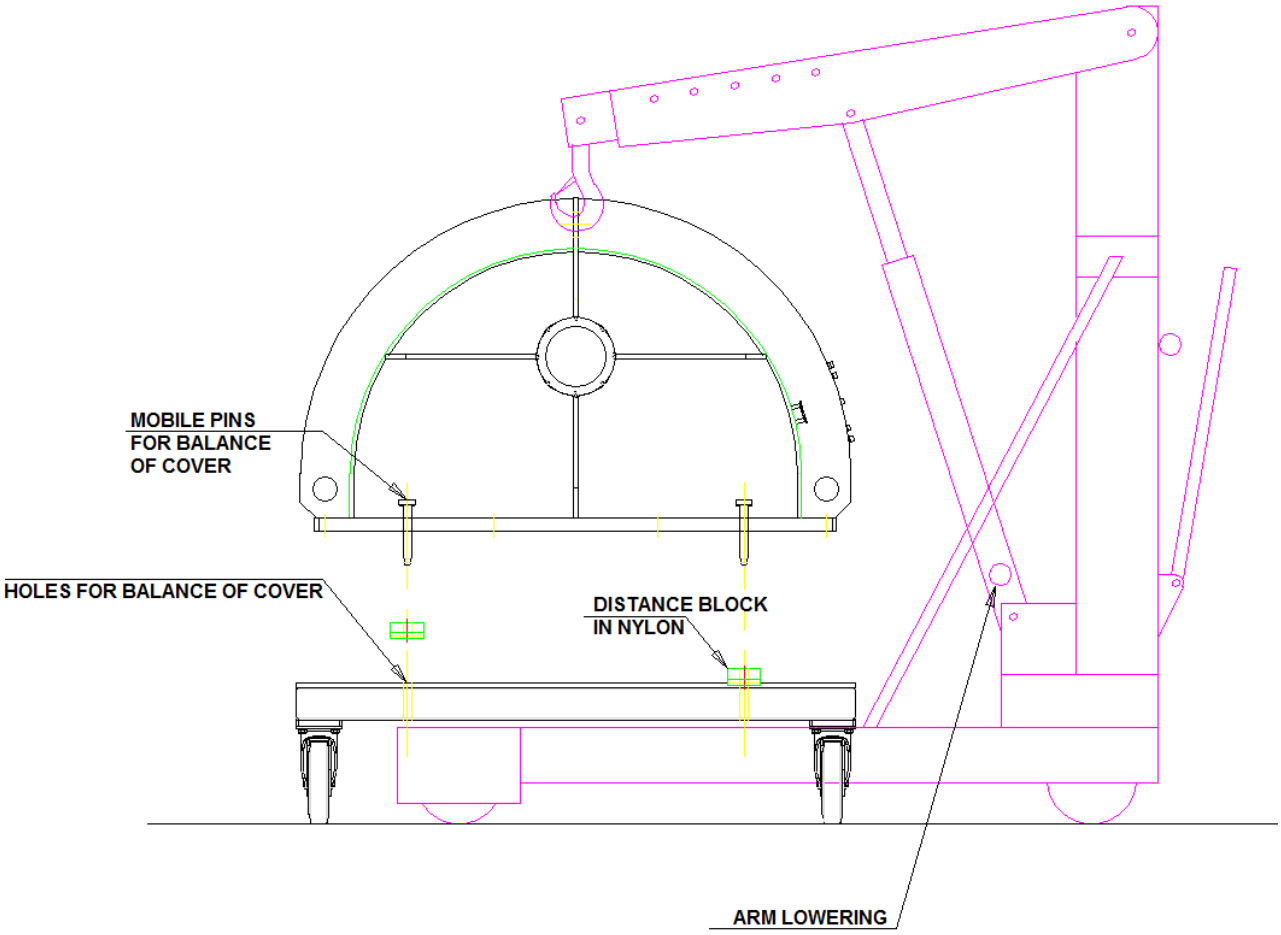
Figure 6: SPOCC cover handling procedure – SHEET 2

c. Positioning the cover on trucks

This section describes step-by-step the right procedure that the personnel must follow in order to place the cover on the trucks.

1. Place the trucks near the chamber, rest the nylon spacers near the guide holes (refer to Figure 7) and set up the four centring spikes.
2. Move behind the lifting device, holding up the cover, until this one is out of the area up to the optical bench. Perform this activity avoiding cover oscillations or abrupt movements.
3. Place the cover above the trucks and insert the four centring spikes in the dedicated holes on the cover.
4. Lower the cover on the trucks using the lifting device handwheel.
5. Centre the cover on the trucks using the spikes.
6. When the spikes are centred, remove the nylon spacers.
7. Distance yourself from the cover, only the operator moving the lifting device is allow staying.
8. Lower the cover until it touches the trucks.
9. Remove the hook from the cover to move it.

Refer to the related scheme in Figure 7 (SHEET 3).



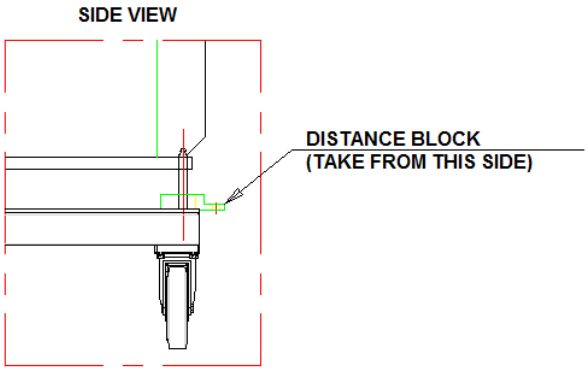


Figure 7: SPOCC cover handling procedure – SHEET 3

d. Closure of the cover

The procedure related to the closure of the cover is similar to the schemes described in the previous sections.

1. Rest the nylon spacers on the basement near the guide spikes.
2. Lift up the cover using the lifting device lever.
3. Place the cover above the chamber basement.
4. Verify the absence of any obstacle between the cover and the basement.
5. Remove the trucks centring spikes from the cover;
6. Lower the cover making sure of insert the spikes in the dedicated cover holes.
7. Once the spikes have been inserted remove the nylon spacers.
8. Distance yourself from the chamber, only the operator moving the lifting device is allow to stay.
9. Lower the cover until it touches the chamber basement.
10. Remove the hook from the cover.
11. Stretch out the folding part that connects the cover to the rest of the chamber and fasten the bolts.
12. Insert all the fixing bolts between the cover and the base of the chamber and fasten them.

Refer to the related schemes in Figure 5 (SHEET 1) and Figure 6 (SHEET 2).

4. Positioning of payload inside SPOCC chamber

In this section, the payload integration procedures are listed by stages.

- Phase 1: introduce the payload in ISO 7 area.

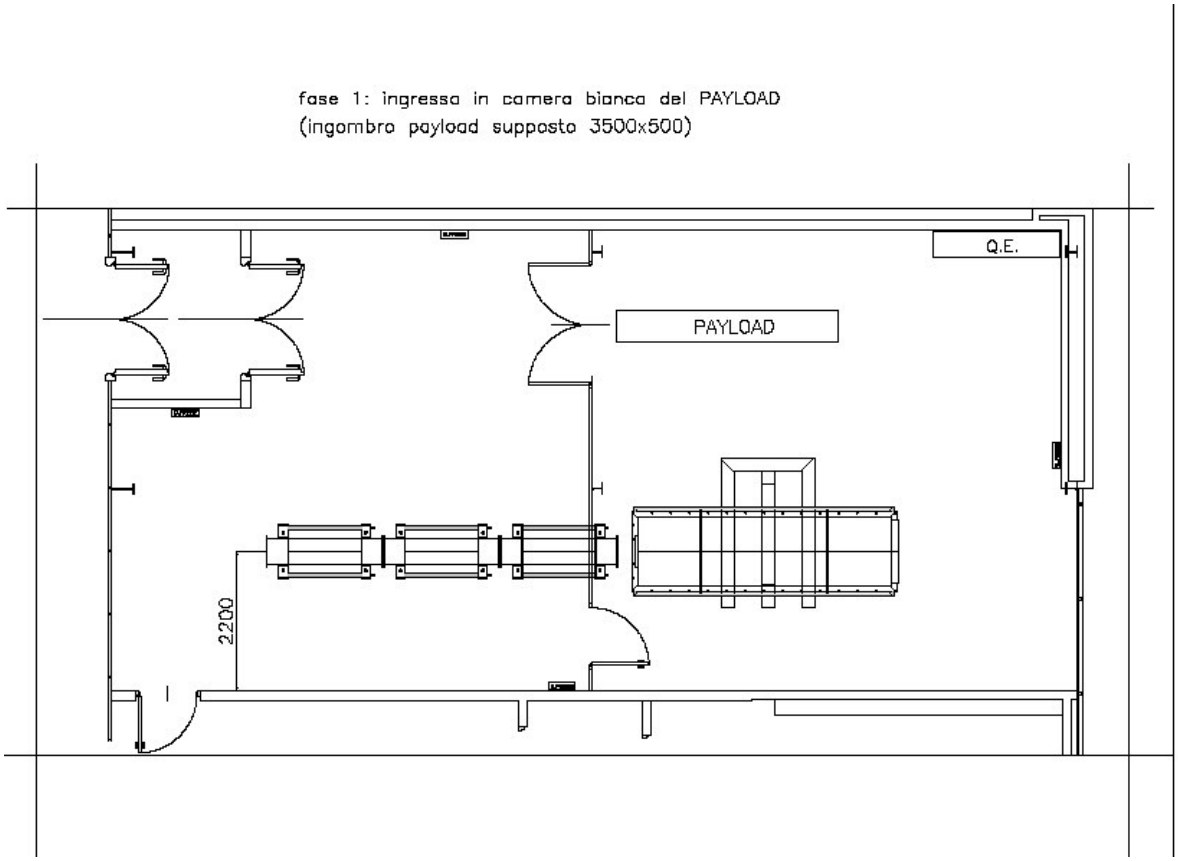


Figure 8: Phase 1

- Phase 2: place the payload on the chamber left corner and remove the SPOCC cover.

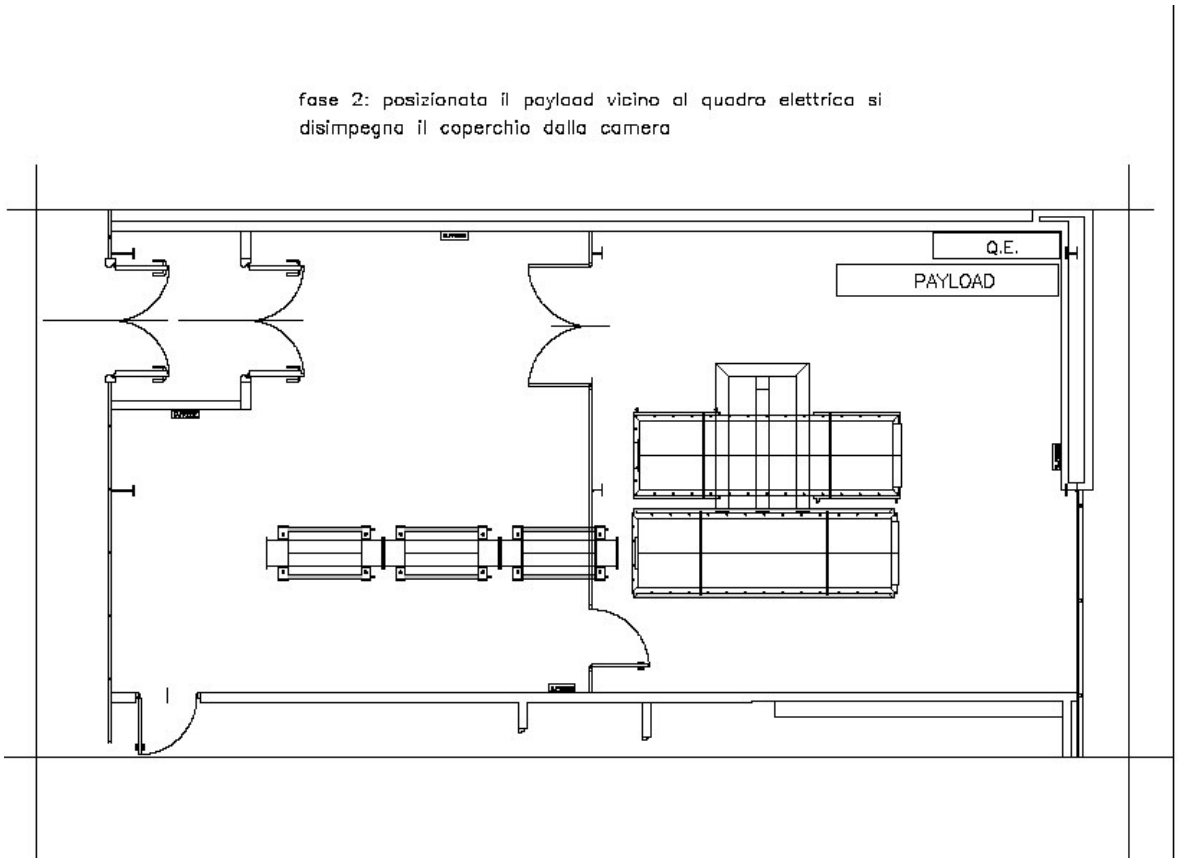


Figure 9: Phase 2

- Phase 3: Set the cover on the trucks and unhook it.

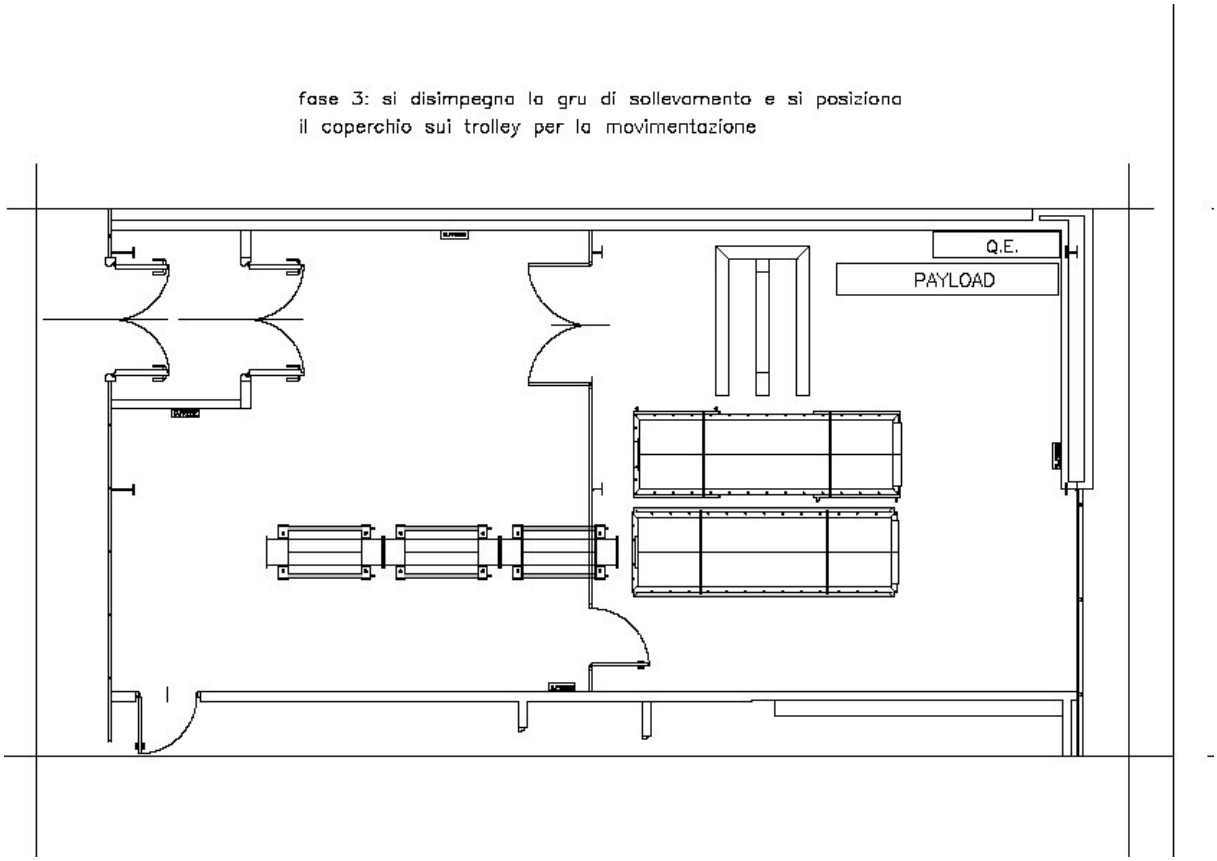


Figure 10: Phase 3

- Phase 4: Place the lifting device near the entrance door.

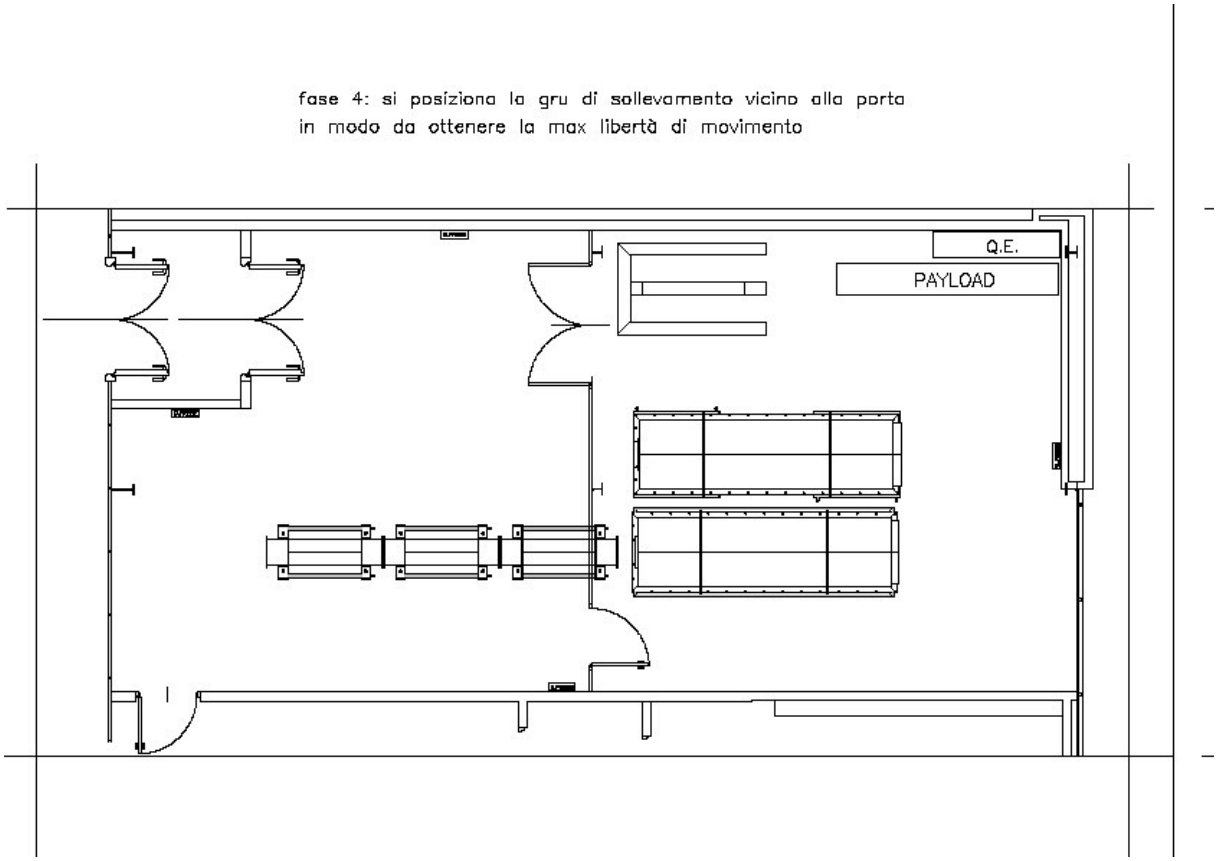


Figure 11: Phase 4

- Phase 5: Move the cover as shown in Figure 12, Figure 13, Figure 14 and Figure 15.

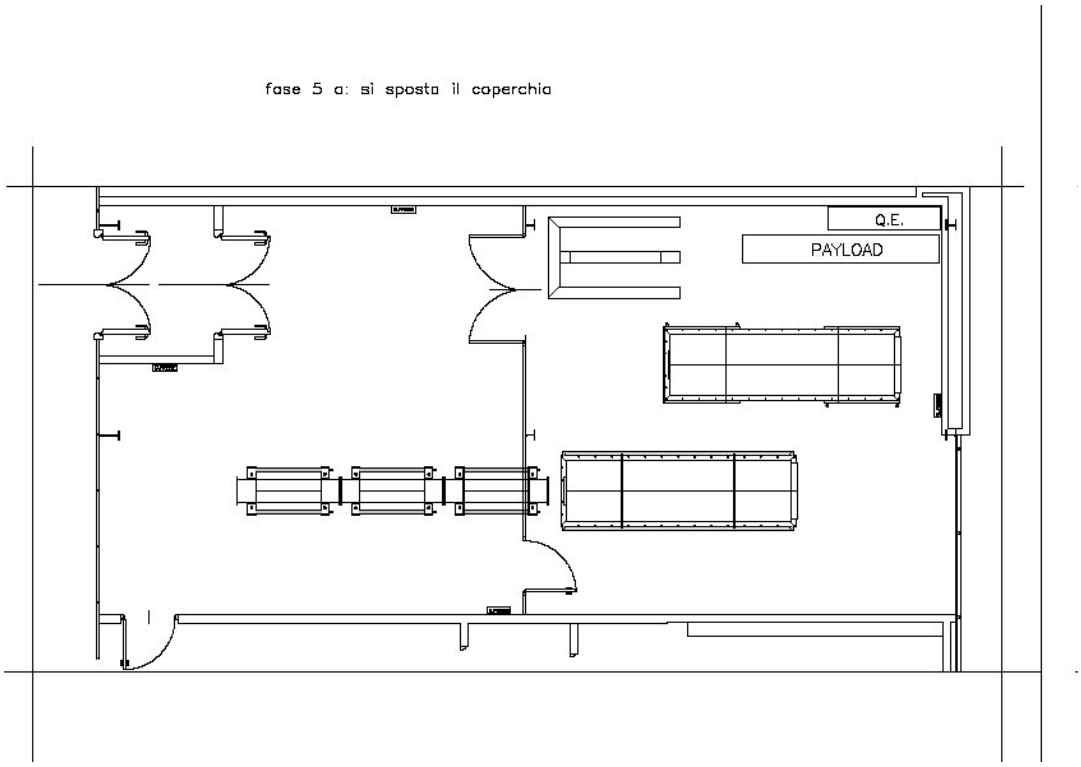


Figure 12: Phase 5a

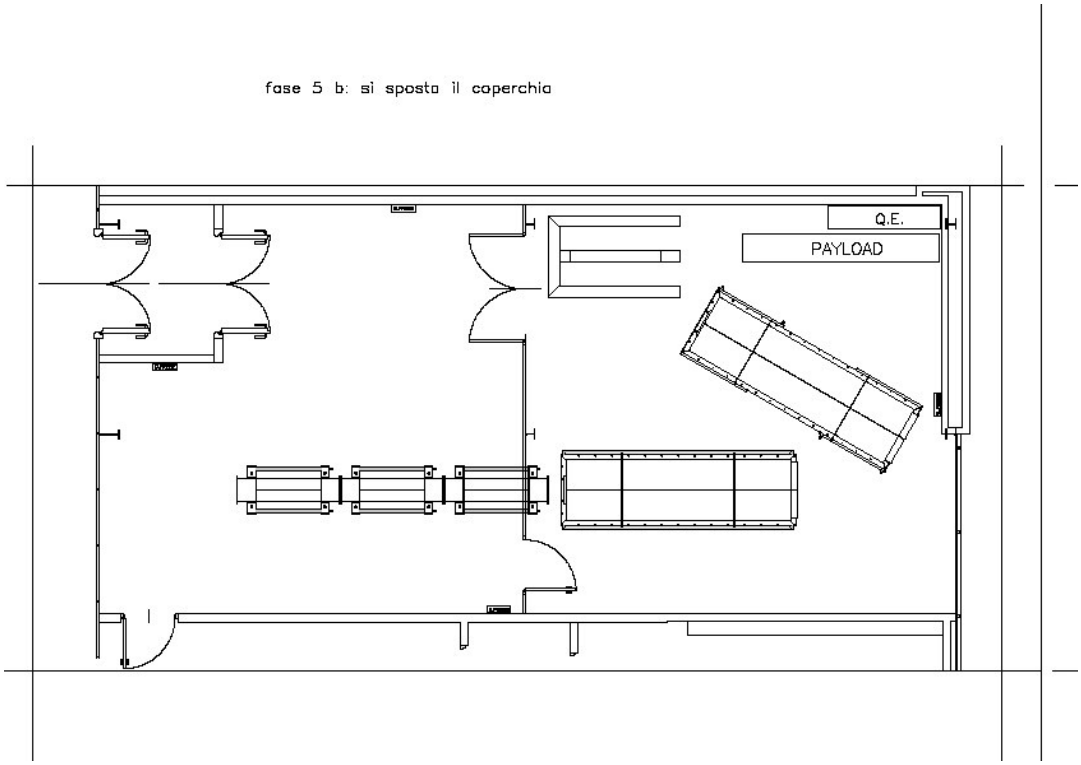


Figure 13: Phase 5b

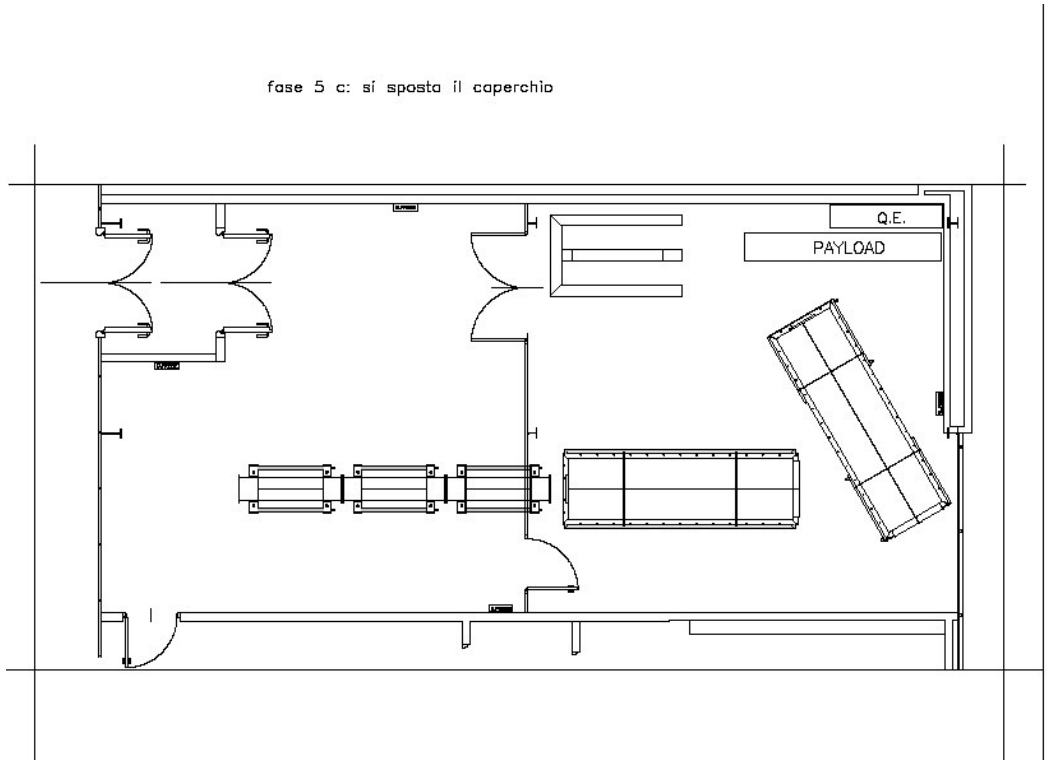


Figure 14: Phase 5c

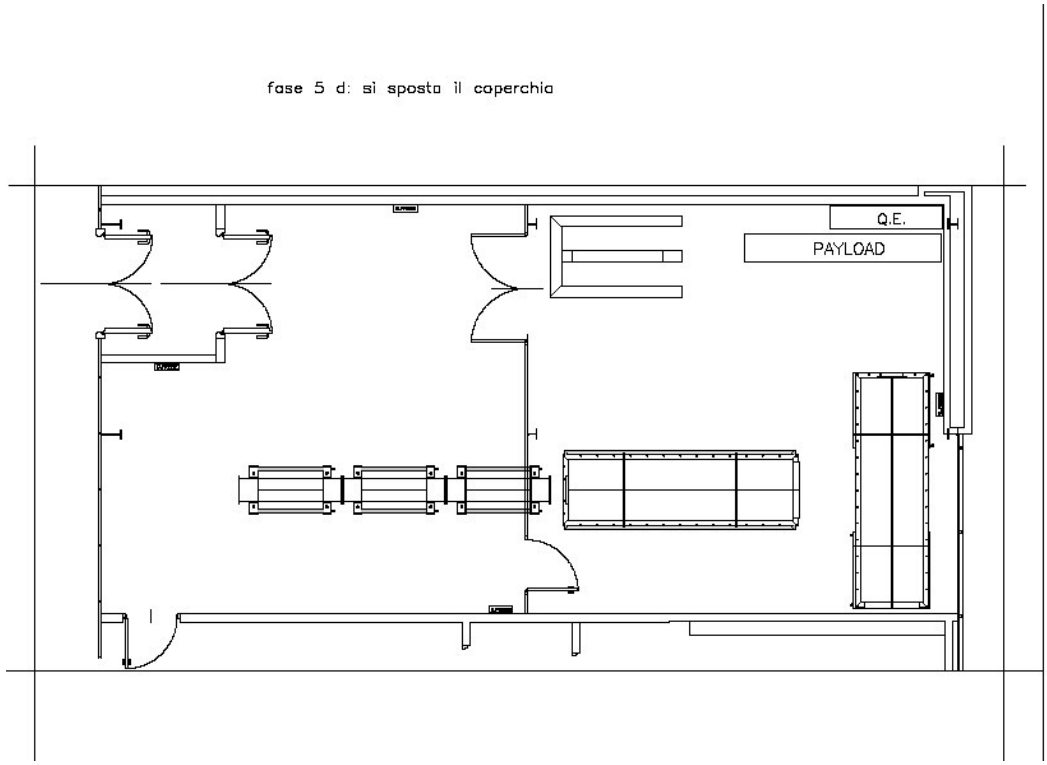


Figure 15: Phase 5d

- Phase 6: Move the lifting device and hook the payload.

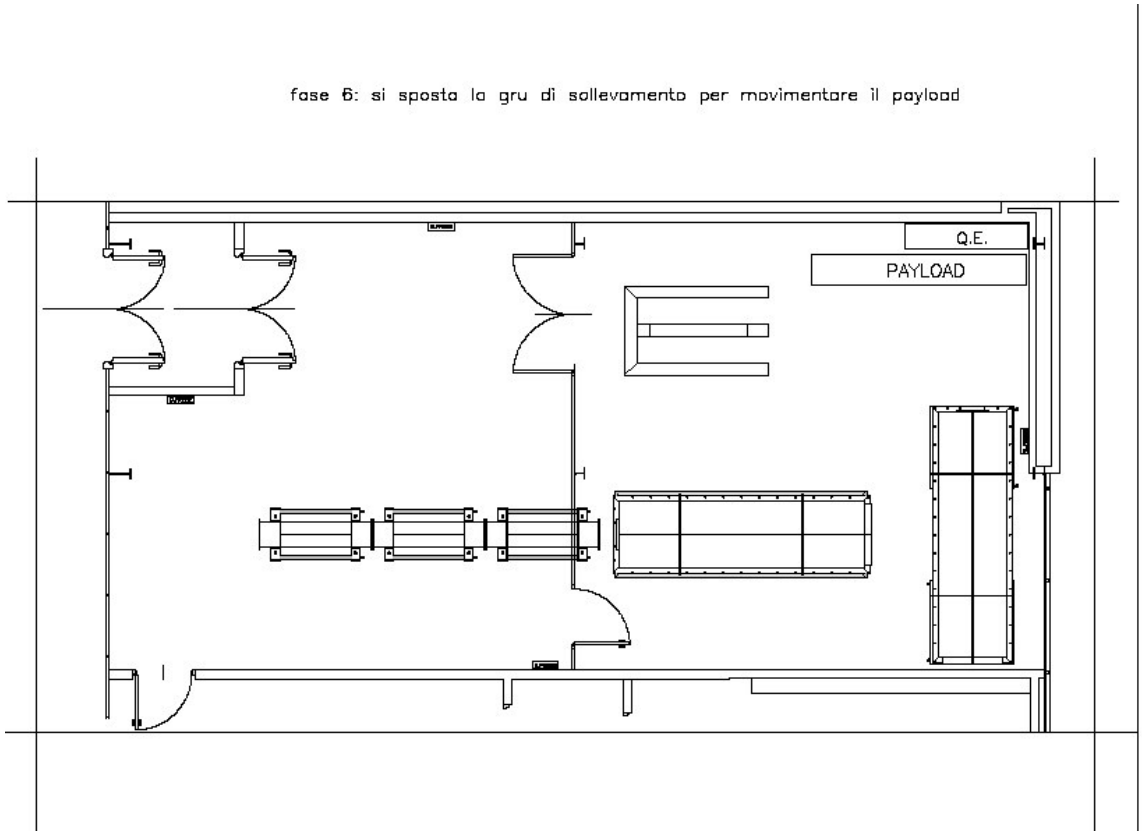


Figure 16: Phase 6

- Phase 7: Set the payload on the optical bench, as shown in Figure 17, Figure 18 and Figure 19.

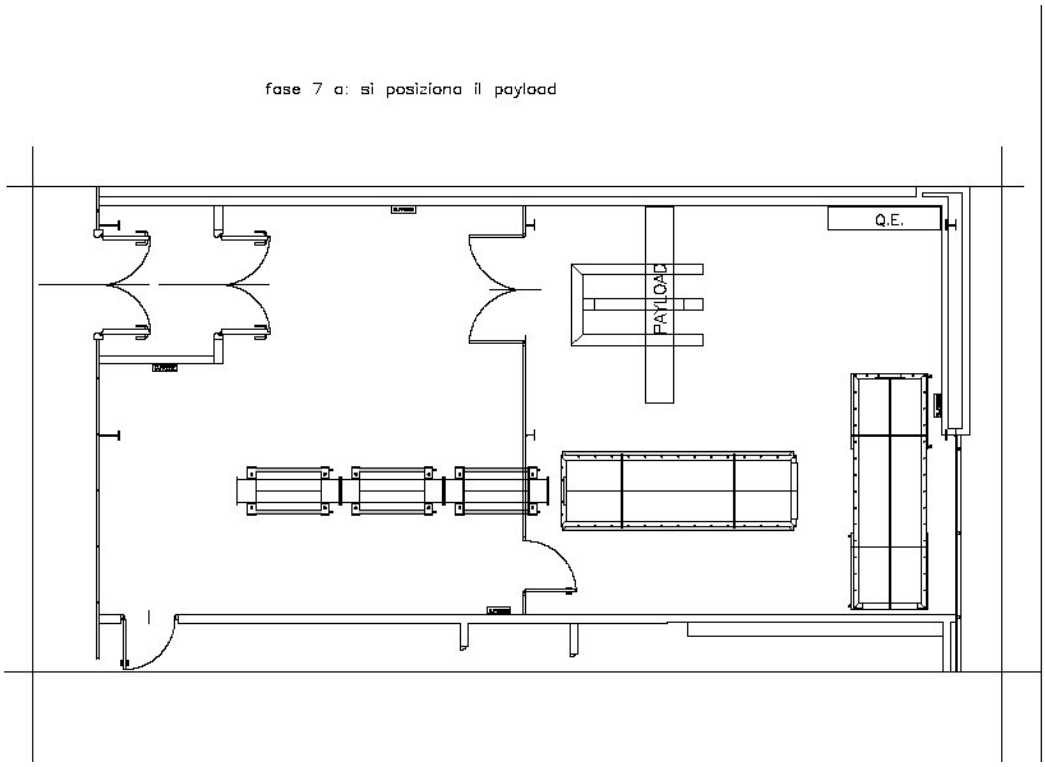


Figure 17: Phase 7a

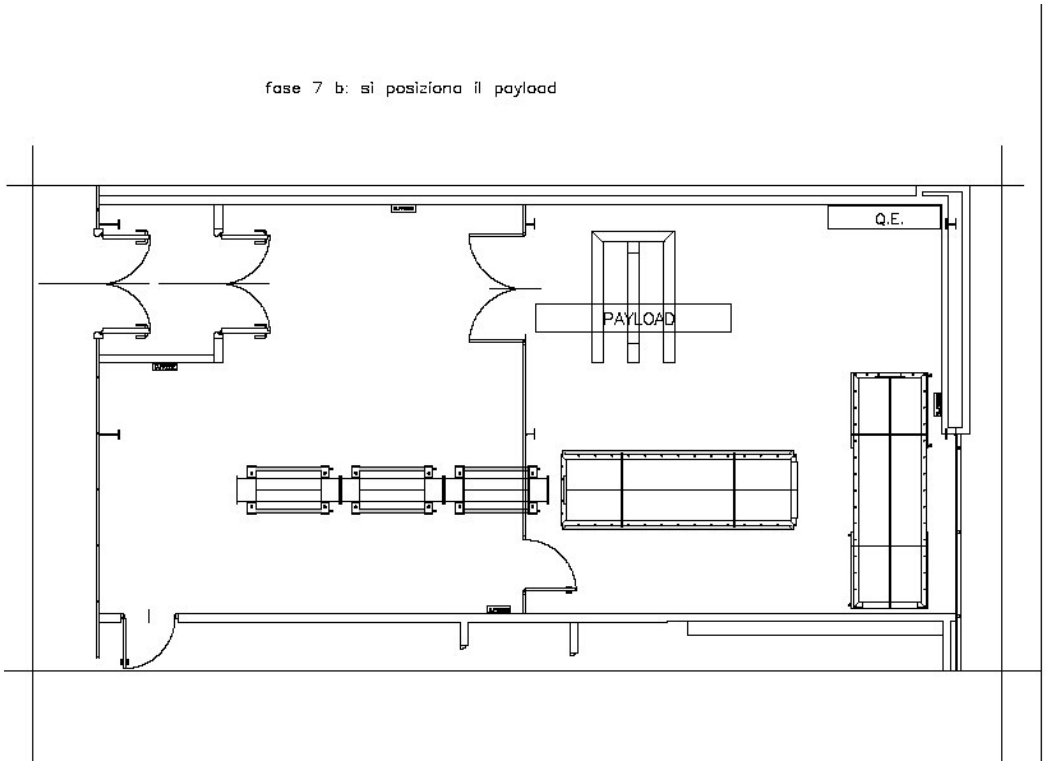


Figure 18: Phase 7b

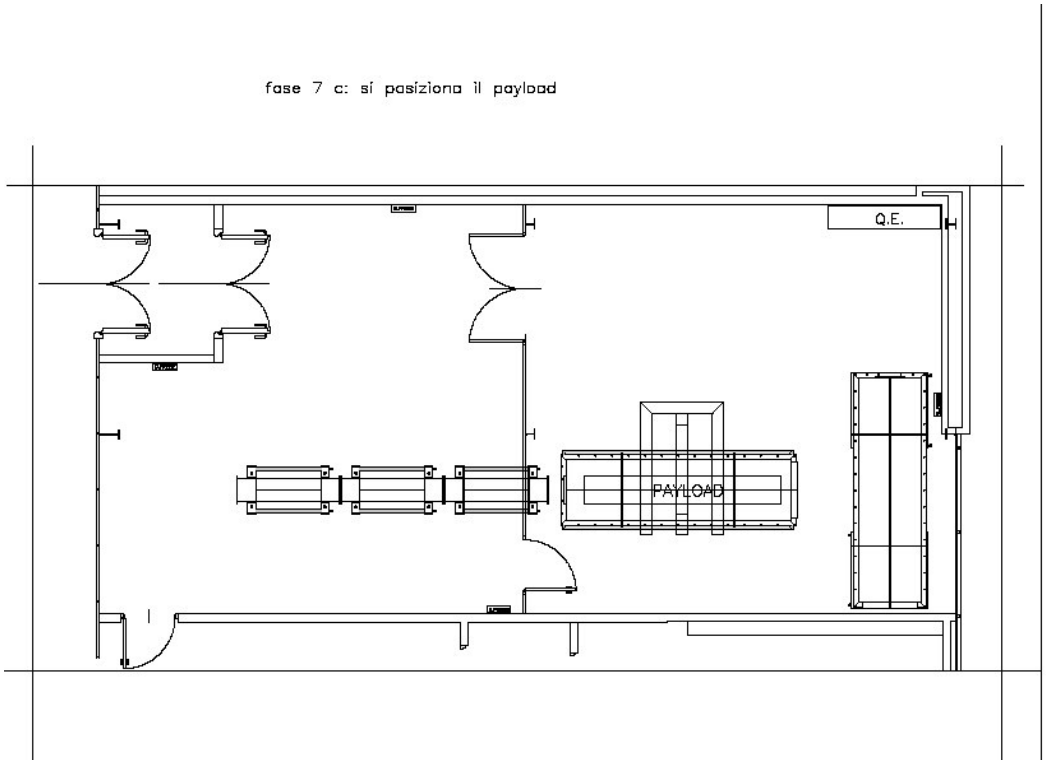


Figure 19: Phase 7c

5. Motorized Optical Bench Operations

The instrumentation under test is positioned in the test chamber, on the optical bench. This is made of aluminium profile. Its dimensions are 900 mm x 3500 mm that is the maximum useful planar surface, whereas the maximum allowed height of the sample is 550 mm. The bench can be tilted in pitch and yaw and translated perpendicularly to the chamber longitudinal axis by two groups of actuators located near both ends. The bench is servo-controlled by a remote computer.

Thanks to these bench movements, it is possible to align, in vacuum, the optical instrumentation in the test section to the sun-simulator located at the opposite side of the pipeline section.

The Optical Bench's Articulation Specifications are collected in detail in Table 6. The adjectives "left" and "right" are intended for an observer standing up at the SPOCC free extremity and looking toward the collimator.

Translation	Vertically (y-axis) left front total stroke	34 mm
	Vertically (y-axis) right front total stroke	40 mm
	Vertically (y-axis) rear total stroke	71 mm
	Laterally (x-axis) front total stroke	40 mm
	Laterally (x-axis) rear total stroke	101 mm
Tilt	Yaw (x-z plane)	± 2°
Tolerances in translation	Resolution	25 μm
	Stability (over 1 hour)	125 μm
	Accuracy	125 μm
	Repetability	50 μm
Tolerances in the angular motion	Resolution	0.3 arcmin
	Stability (over 1 hour)	20 arcsec
	Accuracy	1 arcmin
	Repetability	0.6 arcmin

Table 6: Optical Bench's Articulation Specification

Figure 20: SPOCC Motorized optical bench and cover

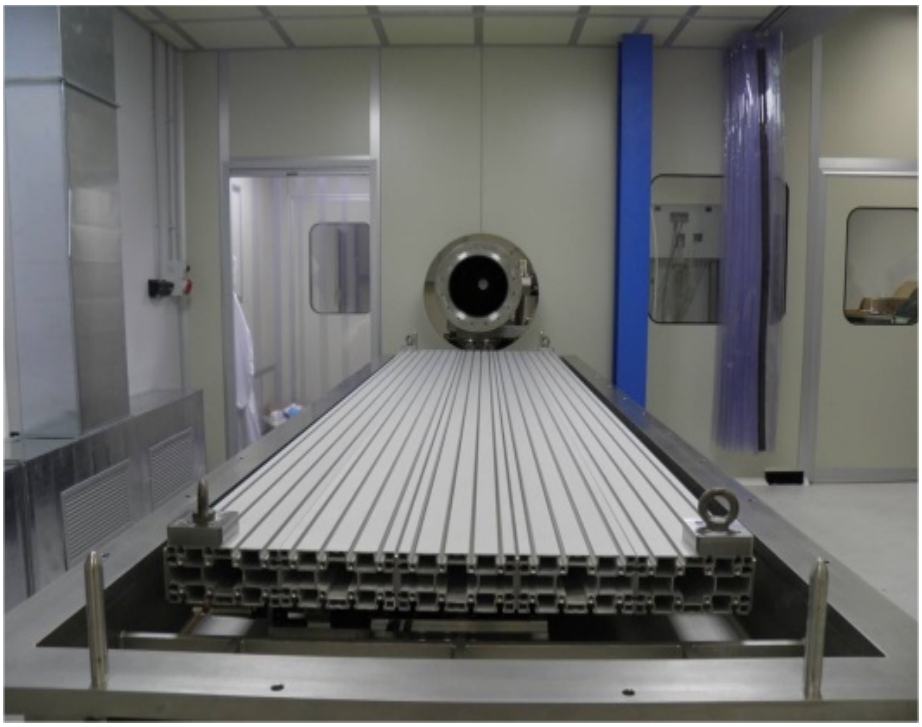


Figure 21: Particular of SPOCC Motorized optical bench

References

[1] Fineschi, S. et al., “OPSys: Optical Payload Systems Facility for testing space coronagraphs”, Proc. SPIE 8148-31 (2011)

[2] Korendyke, C. “Measured Performance and Description of the Naval Research Laboratory Solar Coronagraph Optical Test Chamber and Instrument Clean Room”, Proc. SPIE 1763, 289 (1992)