IECMA 2024 Conference

The 2nd International Electronic Conference on Machines and Applications

18–20 June 2024 | Online

Development of an orthogonal transfer system for the automated warehouse industry

Rafael S. Fonseca, Raul D.S.G. Campilho

Instituto Superior de Engenharia do Porto

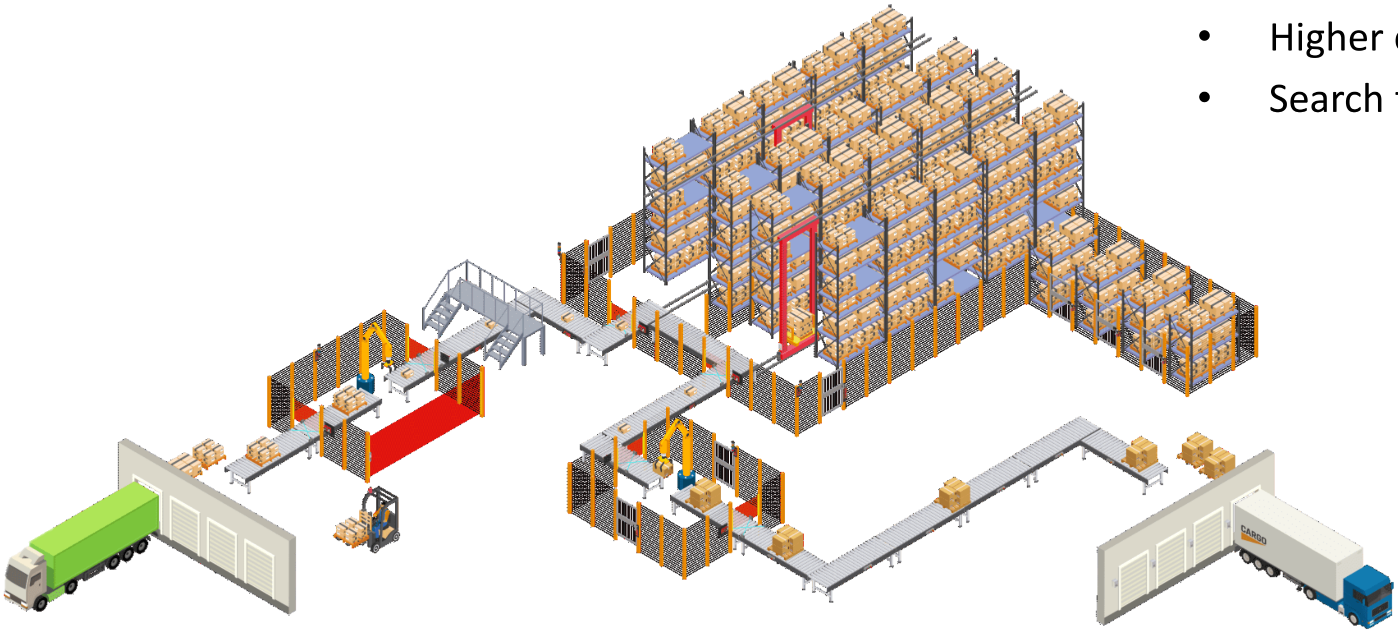
inegi

PRESENTATION LAYOUT

- Context;
- Objectives;
- Presentation of the host company;
- Process description;
- 24V orthogonal transfer;
- Operating principle;
- Mechanical project;
- Conclusions and future work.

CONTEXT

- Automated warehouses



- Combination of control equipment that storage and return materials or objects with a great degree of automation;
- E-commerce;
- Higher consumer demands;
- Search for innovative solutions.

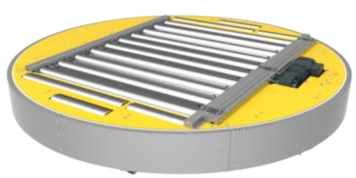
OBJECTIVES

- Development of an ortogonal transfer;
- Standardization of the equipment;
- High flexibility;
- Ease of assembly and maintenance;
- Guaranteed operational safety;
- High construction quality;
- Compliance with all applicable regulations;
- Throughput ≈ 1500 units/h;
- Max load: 50 kg.

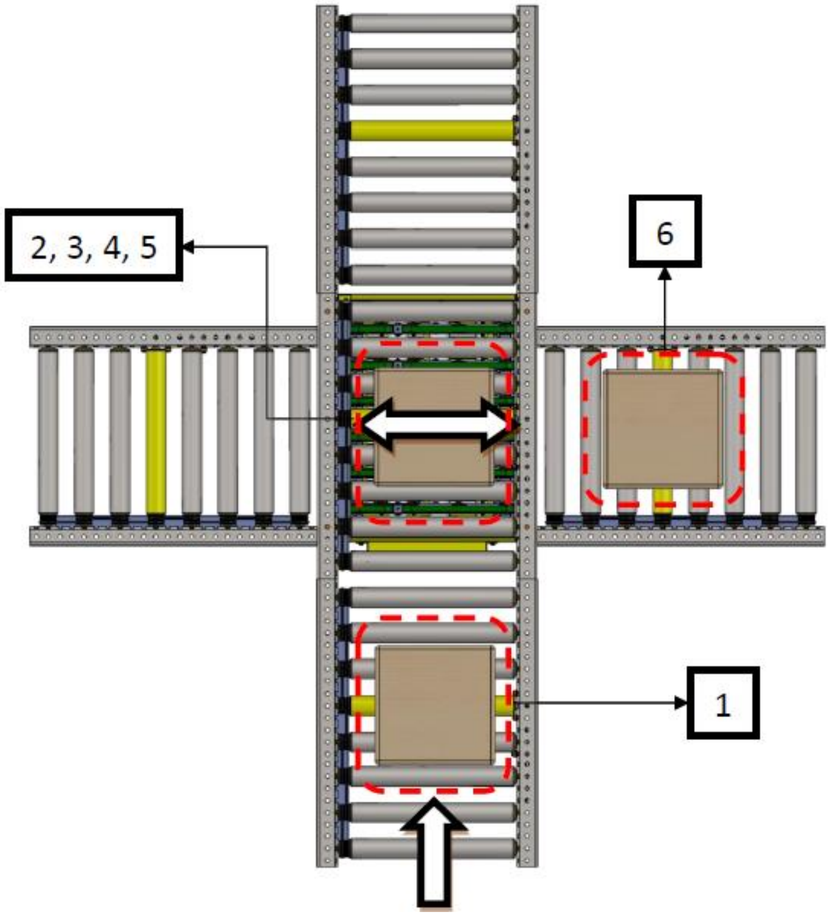
PRESENTATION OF THE HOST COMPANY

antípoda®
engineered to your needs

- Founded in 2002;
- Specialized in intralogistics equipment.

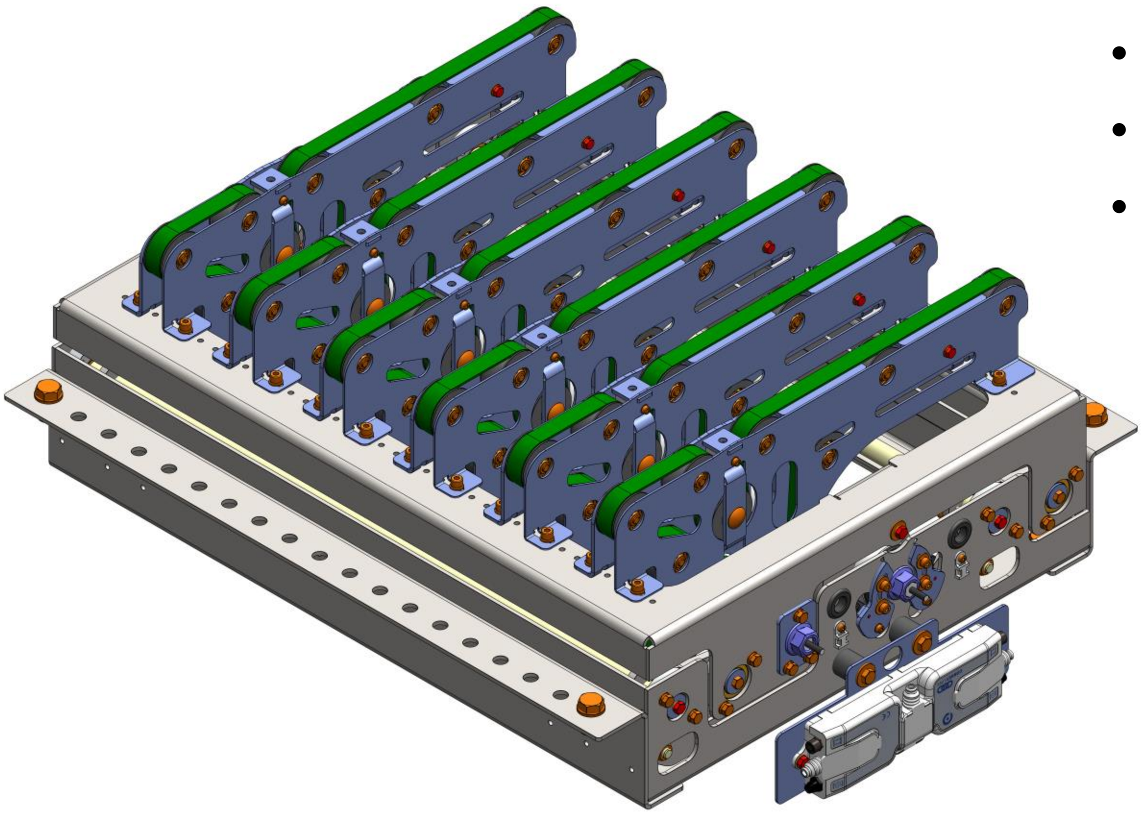
Roller conveyor	Chain conveyor	Turntable	Orthogonal pallet transfer	RGV
				

PROCESS DESCRIPTION



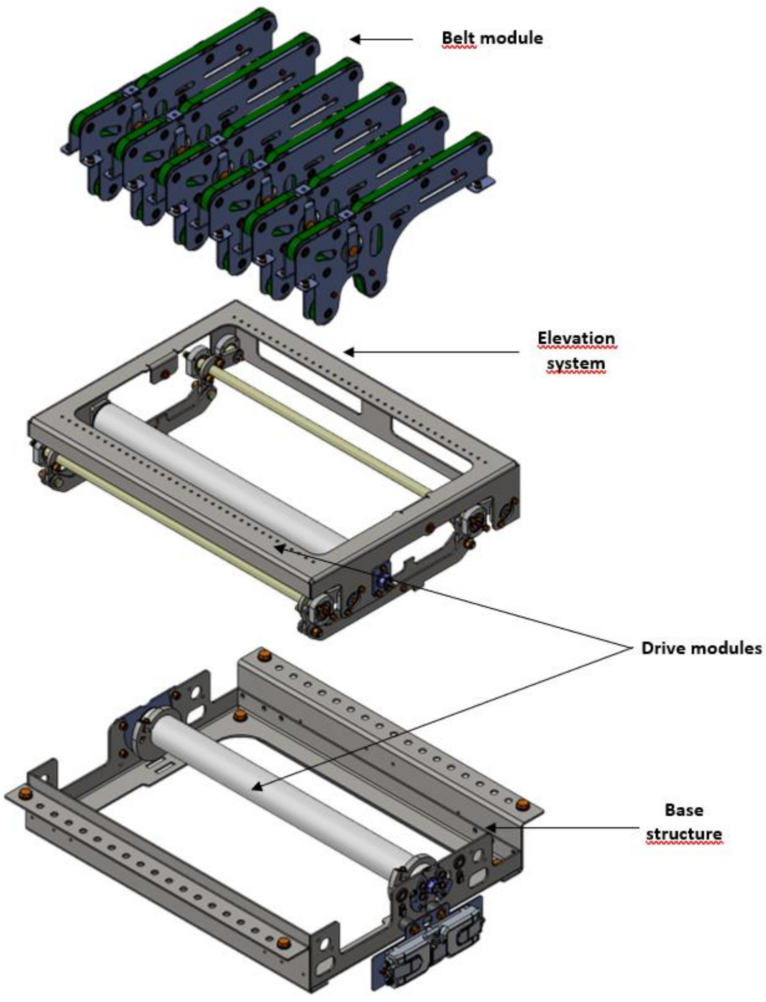
1. The box travels in a roller conveyor;
2. The box is detected by a photovoltaic sensor, ordering the roller conveyor to stop, immobilizing the box in the transfer area;
3. The transfer belts elevate the box;
4. The belts move the box to an adjacent conveyor;
5. The belts return to their original position;
6. The box travels in another conveyor.

24V ORTOGONAL TRANSFER



- Width = 450 mm
- Pitch = 90 mm
- 6 Belts

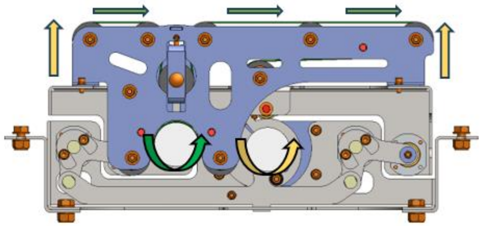
SUB ASSEMBLIES

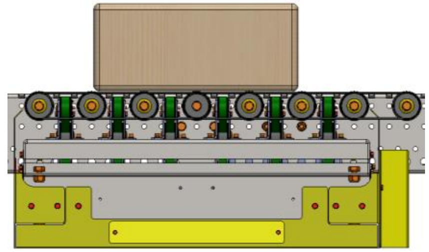


- Belt meets the load and transfers it to another conveyor
- Mechanism guarantees stability during elevation
- 2 Roller drivers, one responsable for the elevation and the other for the activation of the belts
- Base structure that fixes the equipment to a roller conveyor

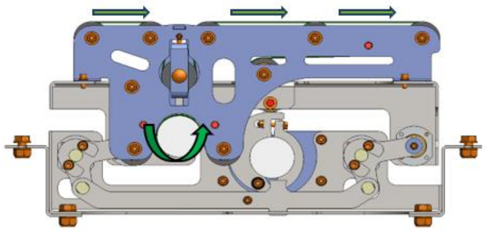
OPERATING PRINCIPLE

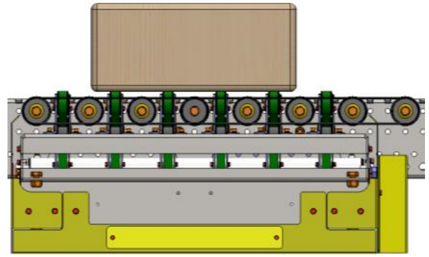
- Detection of the box in the transfer position which stops the roller conveyor;
- Both roller drivers are activated. Belts start moving and the superior structure is elevated;



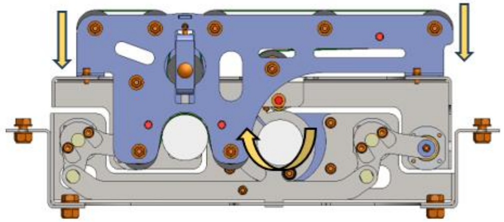


- The belts transport the box to an adjacent conveyor.





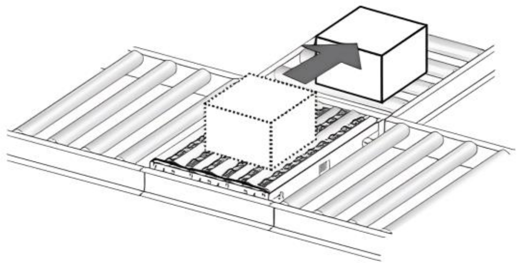
- The belts rollerdriver is desactivated while the other spins in the opposite direction, lowering the superior structure to the original position.



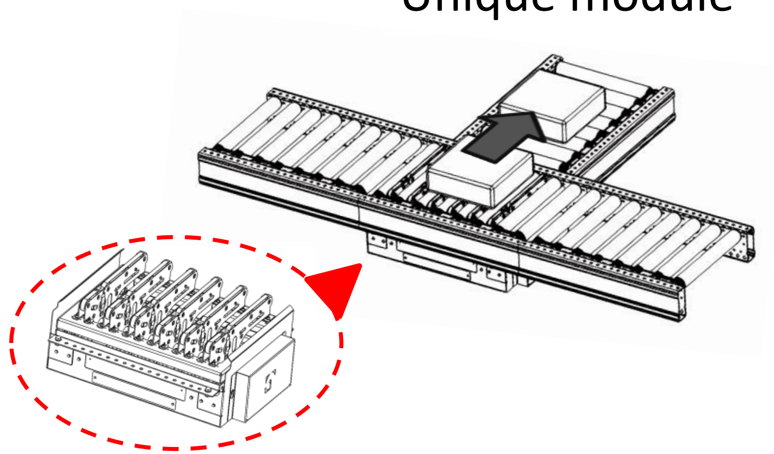
PRE DESIGN

GENERAL CONCEPT

Complete module



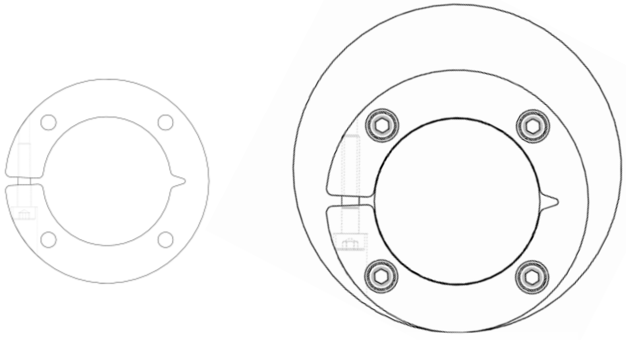
Unique module



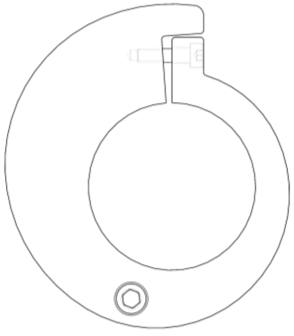
DRIVE MODULE

Gearmotor	Motorized roller	Air spring	Pneumatic cylinder	Electric cylinder
				

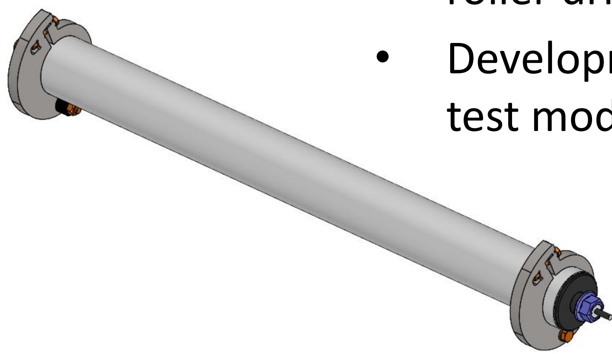
PRE DESIGN – ELEVATION MODULE



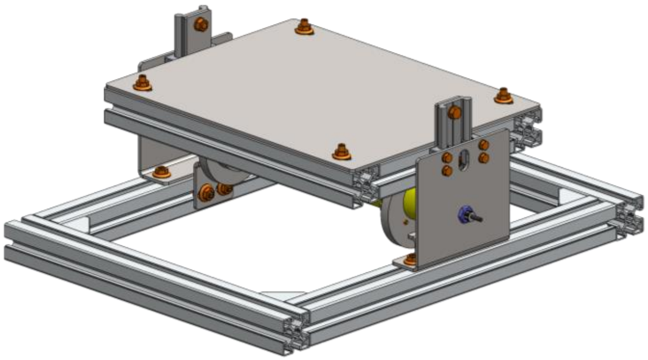
Eccentric cam



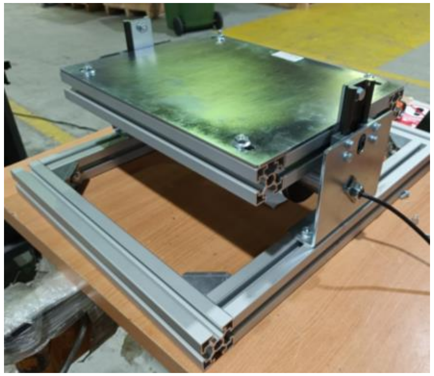
Snail cam



- Design of a system to fix the cam to the roller driver;
- Development of a test model.



Cad version of the test module

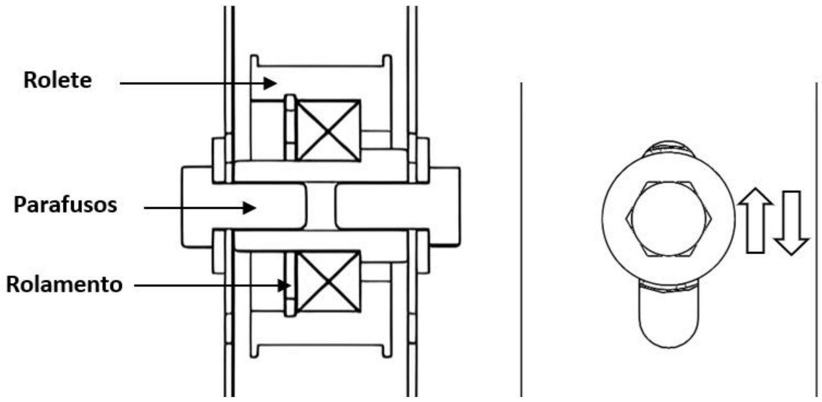


Real version of the test module

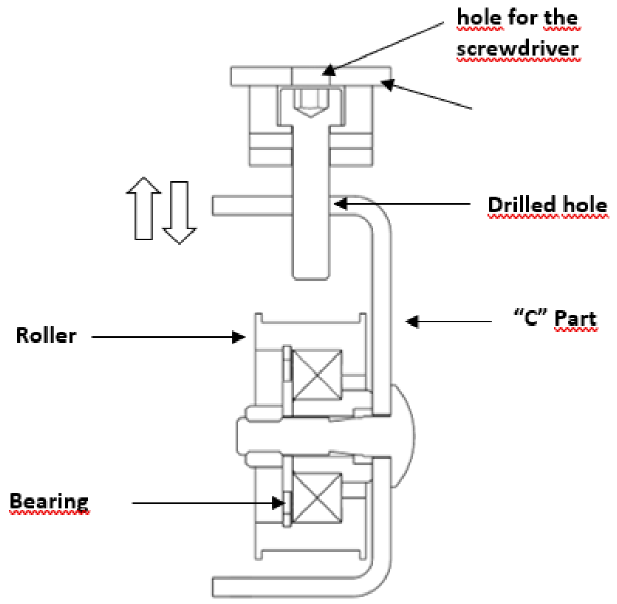
Component	Maximum load (kg)
Eccentric	23
Snail	37

Test results

PRE DESIGN - TENSIONING MODULE

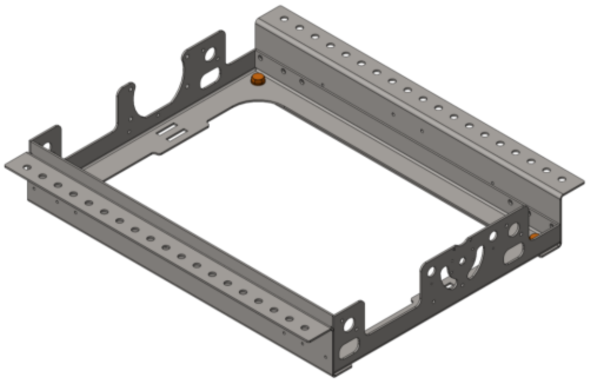


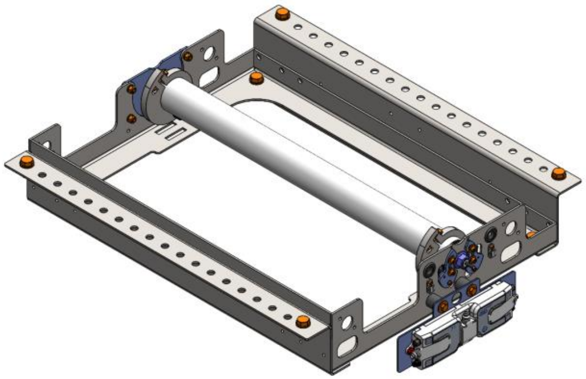
Simple module

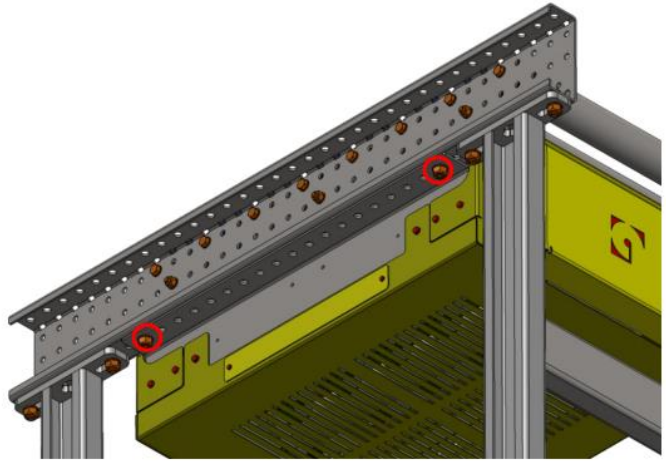


Complex module

DESIGN - STRUCTURE







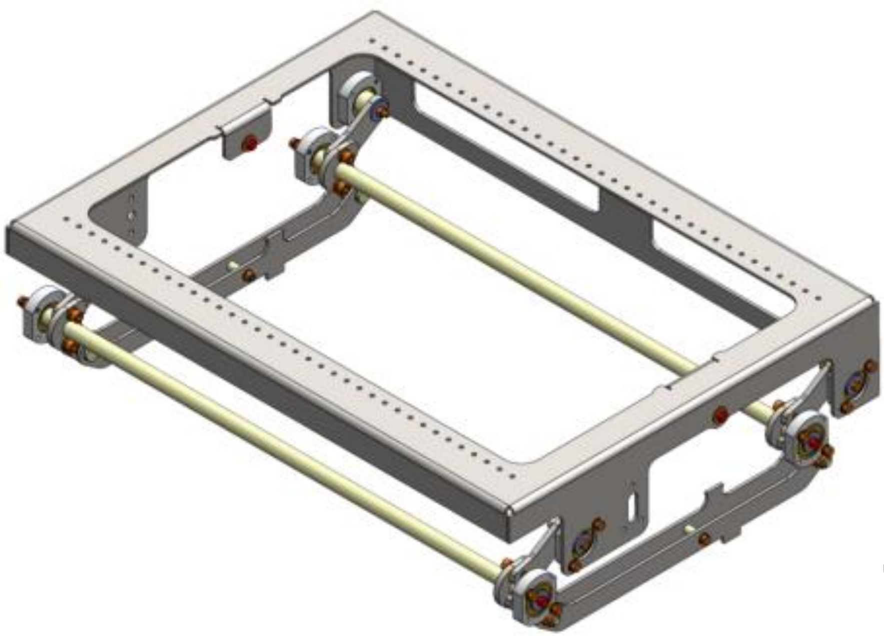
Structure

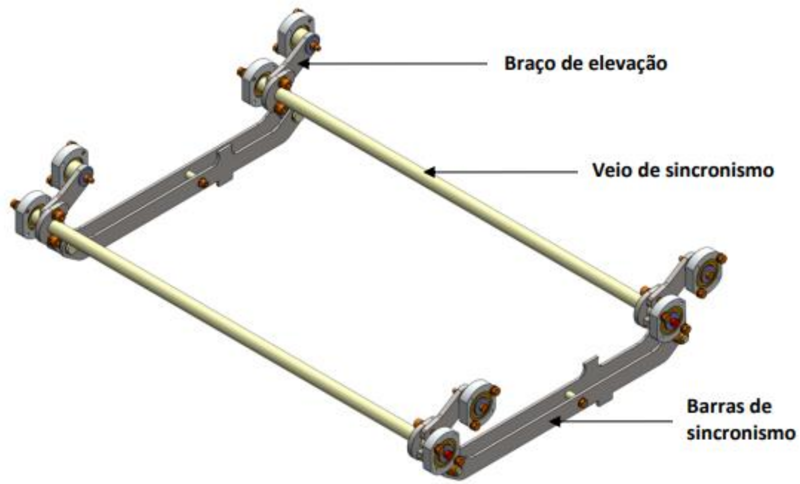
- Composed by 3 parts bolted together;
- Bent sheet metal;
- Windows to facilitate access during maintenence.

Anchor points

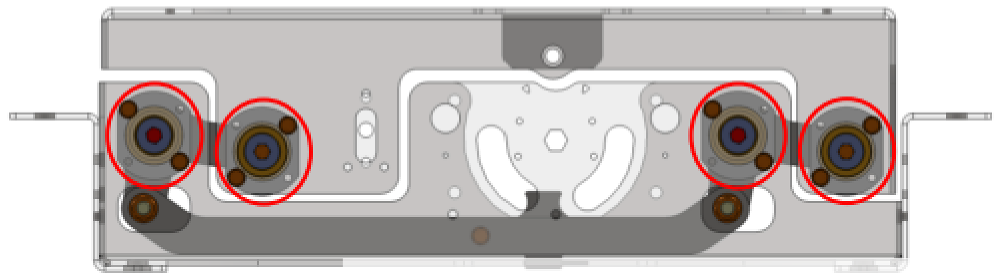
- Same pitch between holes as the stadard conveyor for high placement flexibility

DESIGN – ELEVATION MODULE



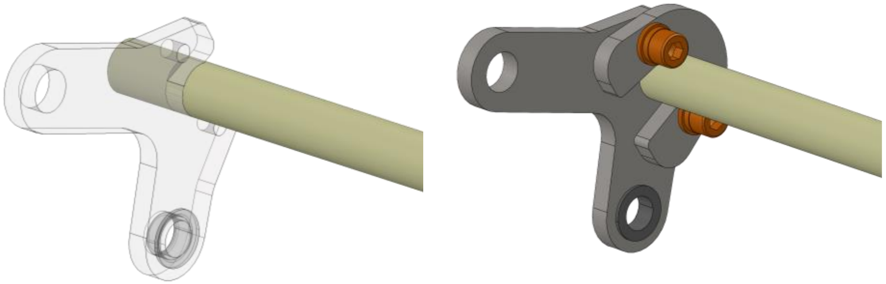


Synchronism module

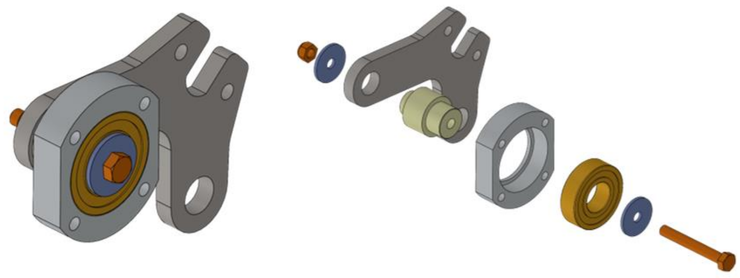


Fixing points

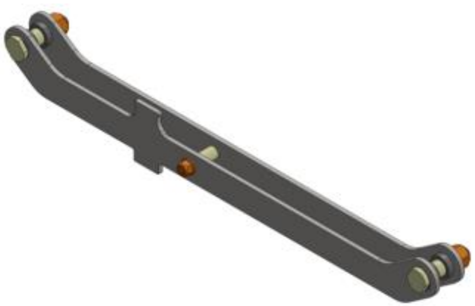
DESIGN – ELEVATION MODULE



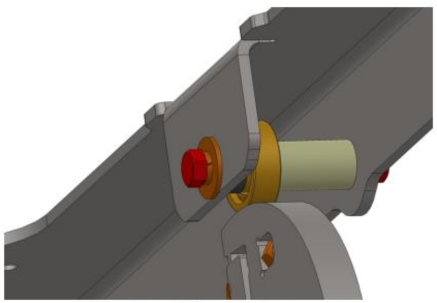
- Longitudinal synchronism (detail)



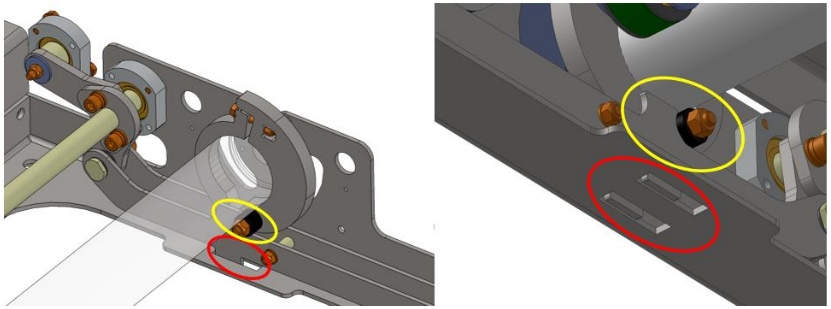
- Elevation arm and superior structure link



- Transversal synchronism (detail)

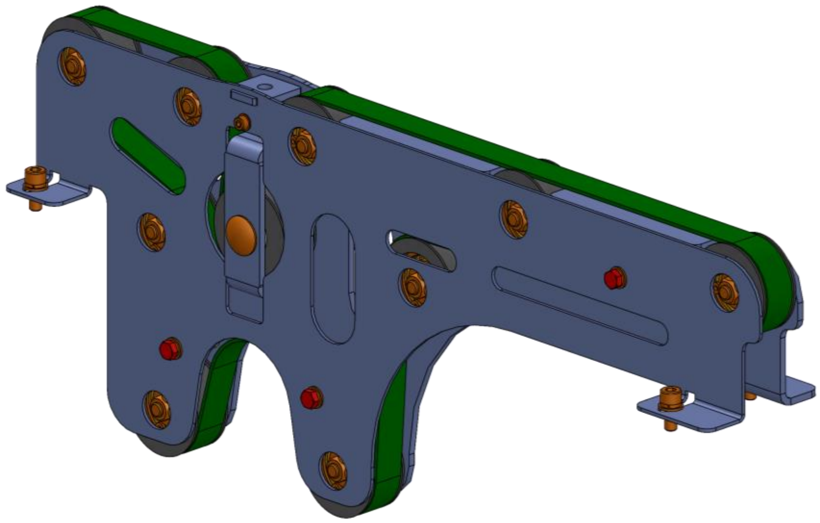


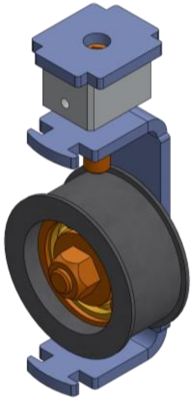
- Contact point between the snail cam and a bearing



- Stopper (double redundancy)

DESIGN – BELT MODULE





Belt tensioner module

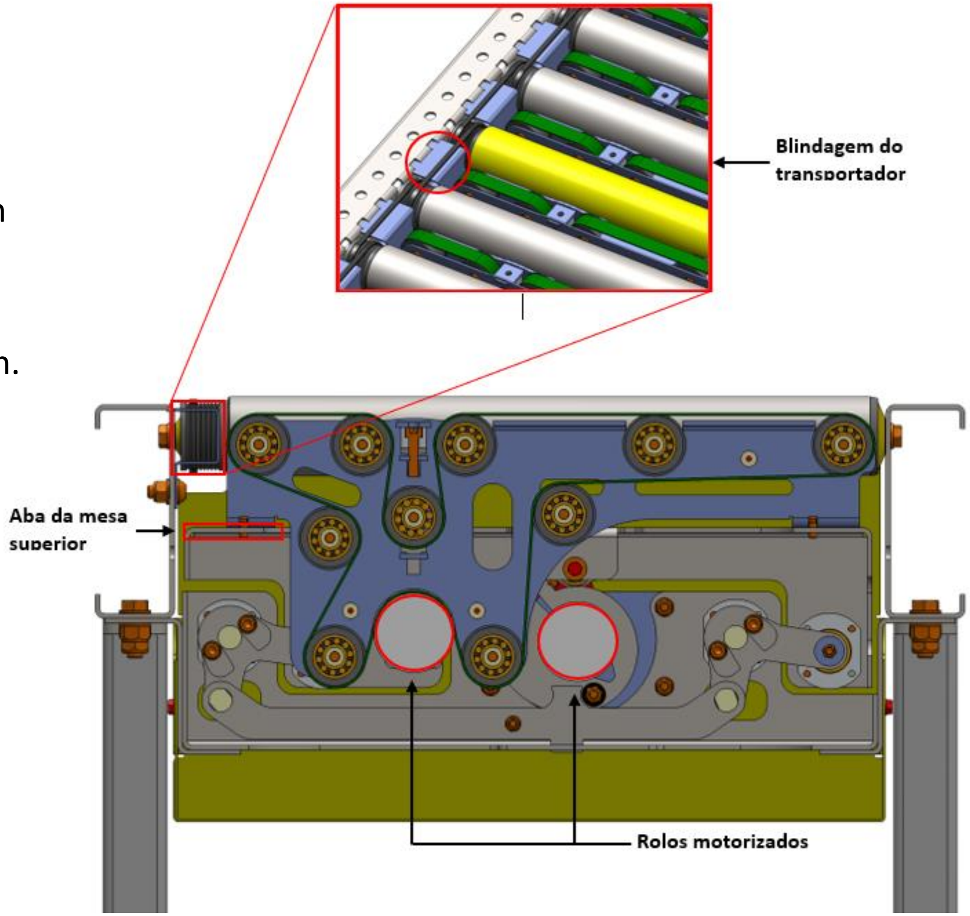
Roller assembly

- Two bent sheet metal parts for structure;
- 10 rollers;
- Tensioner module;
- 3 steel shafts to increase stiffness;
- Horizontal tuning option.

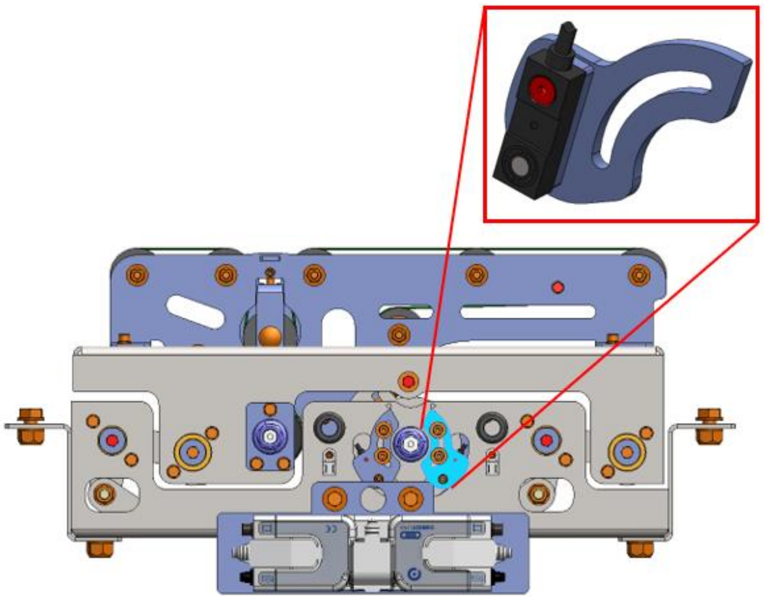
DESIGN – BELT PATH

Design constrains

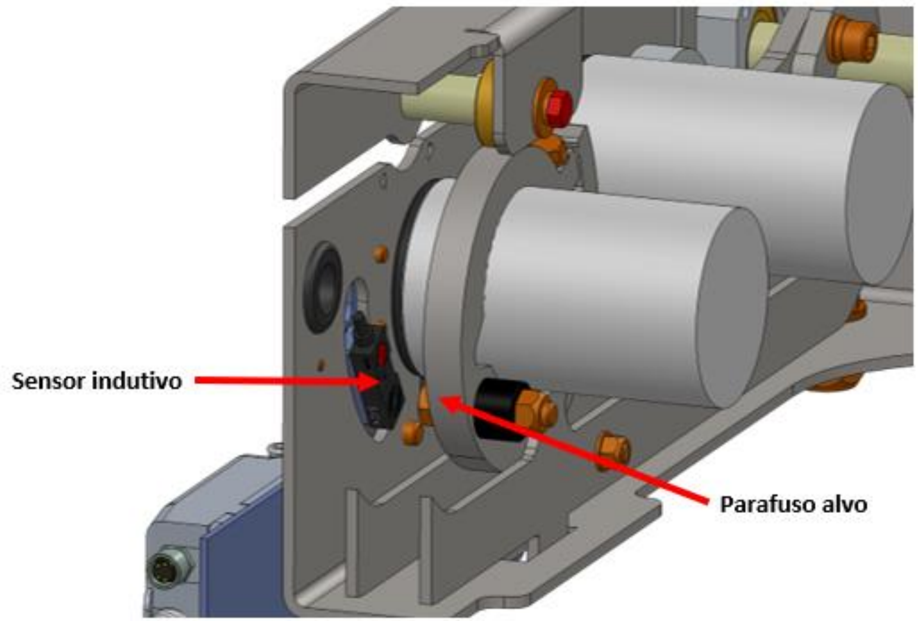
- Conveyor transmition shield;
- Table top;
- Roller drivers position.



DESIGN - CONTROL SYSTEM

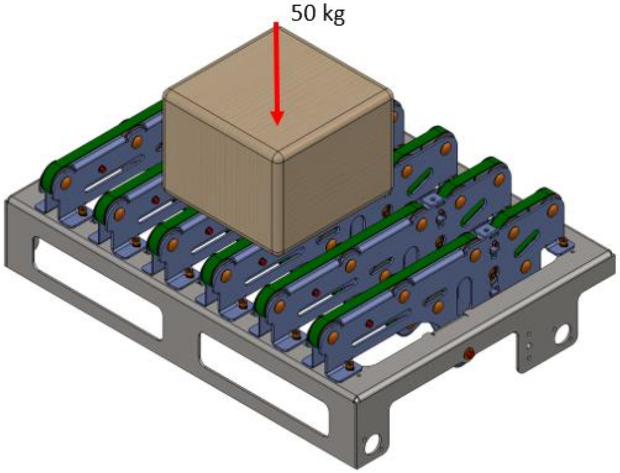


Sensor positioning
with tuning



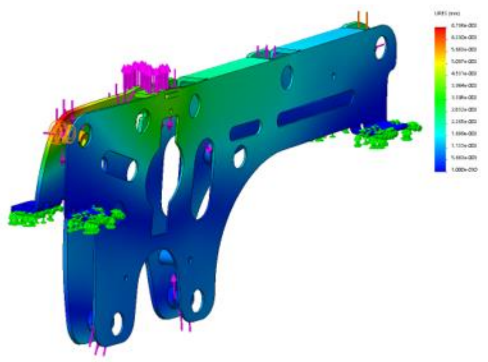
Sensor and target bolt
with tuning

DESIGN - FEM



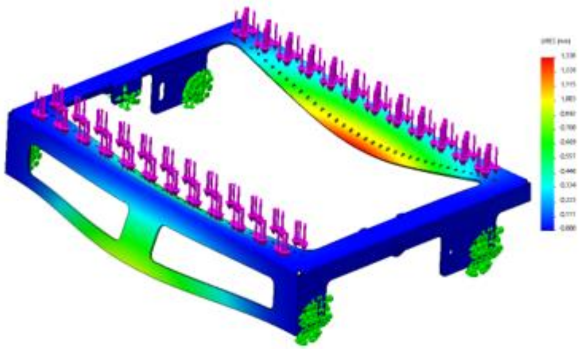
Critical case

Belt module



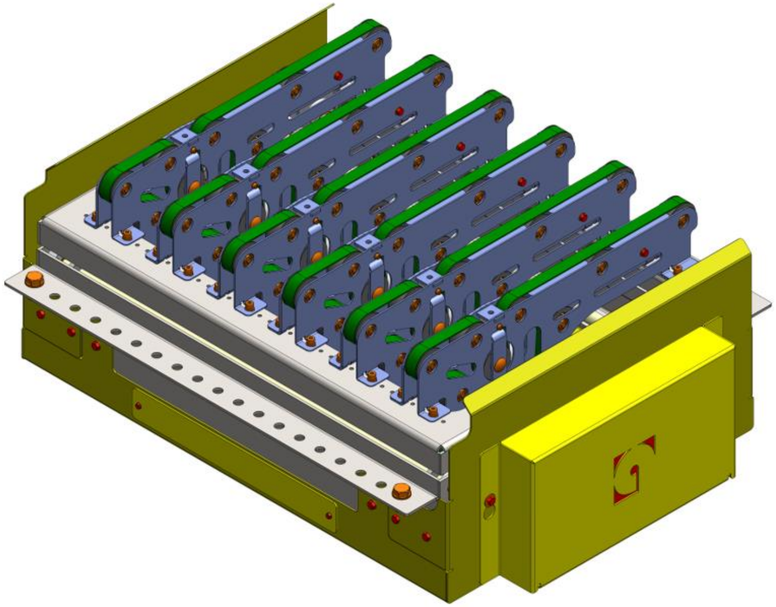
Maximum von Mises stress [MPa]	**≈ 20**
Resultant displacement [mm]	0,12
Safety coefficient	11,75

Superior structure

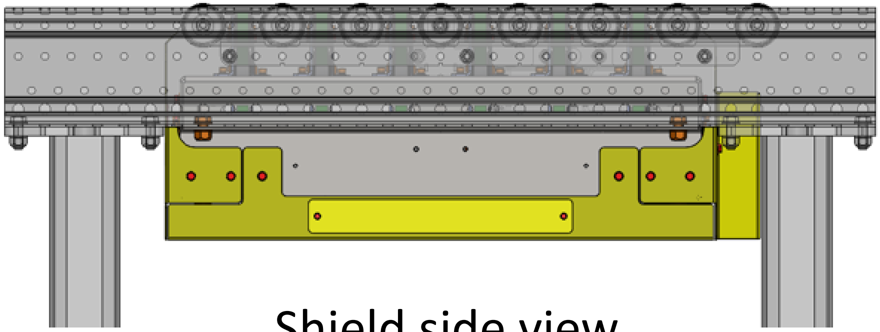


Maximum von Mises stress [MPa]	**55,7**
Resultant displacement [mm]	1,338
Safety coeficiente	4,2

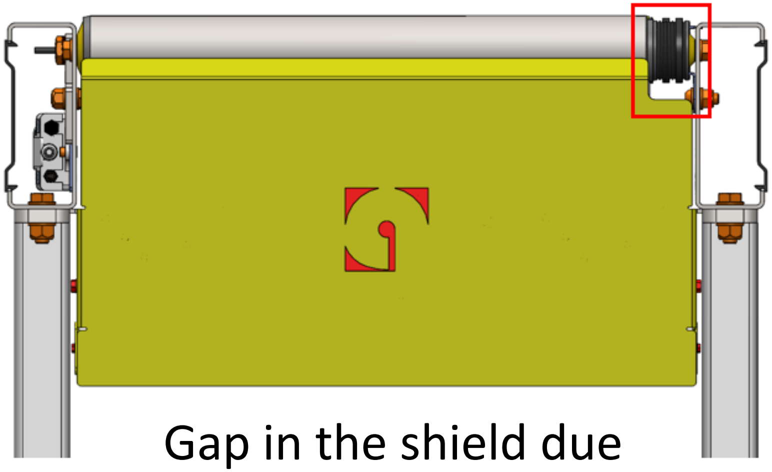
DESIGN - SHIELDING



24 V transfer with shields

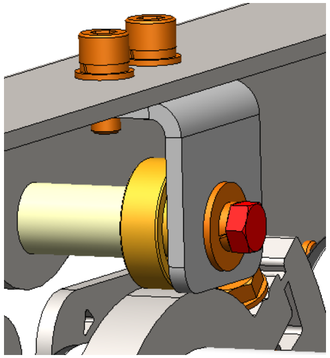


Shield side view

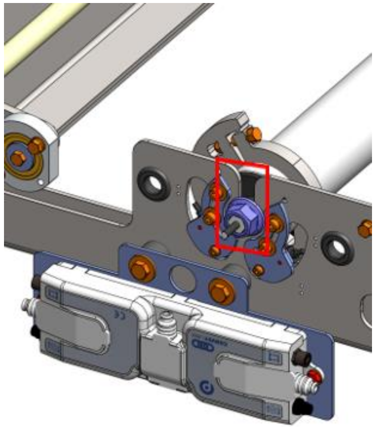


Gap in the shield due to poly-v transmition

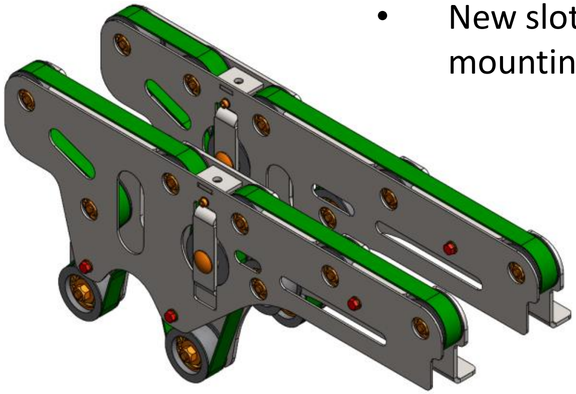
ASSEMBLY AND TESTING



- Bearing support change



- New slot in the base structure to allow easier mounting of the Roller driver



- New belt module

TESTING

- No-load test

- 50 kg test – continuous cycles

Box weight [kg]	Cycle time [s]	Throughput [units/hour]
10	≈ 1,6	2250
30	≈ 1,8	2000
50	≈ 2,0	1800

- Test results for multiple box weights

CONCLUSIONS AND FUTURE WORK

Conclusions

- 50 kg box elevation was achieved;
- Throughput of 1500 units/h was surpassed;
- During testing was possible to verify that the equipment is capable of handling the previous conditions with high reliability.

Future work

- Further FEM optimization
- Using the elevation mechanism to develop diferent types of transfers (timing belt / 45° diverter)

Instituto Superior de
Engenharia do Porto