eQart®

Risk Analysis.

Date: 09/2020

Revision: 1.0
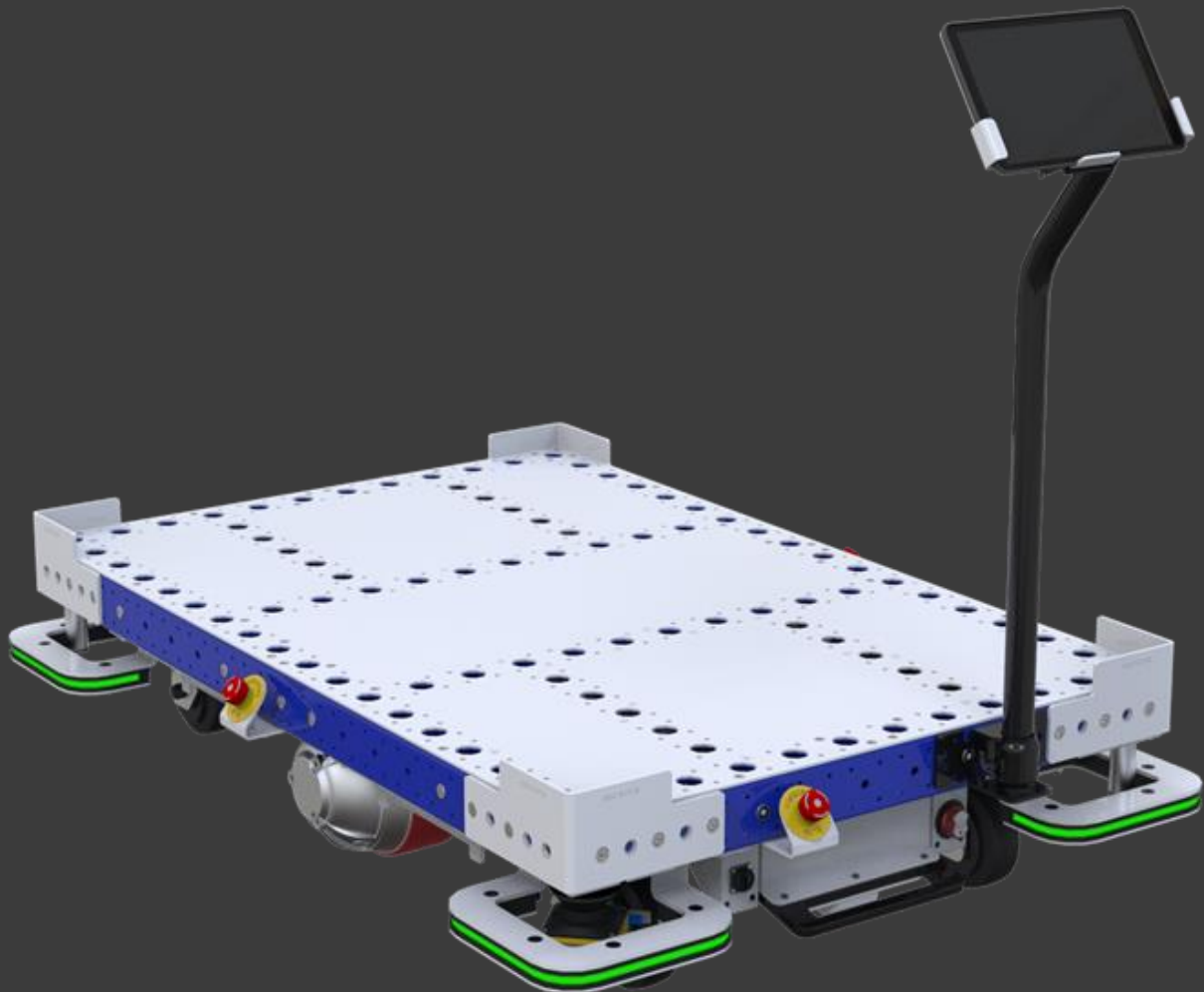
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1 Introduction to this document

This document will describe the Risk analysis of the standard eQart platform according to the applicable safety standards. The eQart is certified according to the Machinery directive 2006/42/EC which requires a risk assessment according to ISO 12100:2010.

The risks identified and evaluated in this document is describing the most common scenarios for the eQart. The specific user scenarios and application risks are not included in this document, but it can be used as a template for the risk analysis during implementation.

1.1 Document history

Revision	Release date	Description
1.0	Sep 2020	Initial release

1.2 eQart Certification

the eQart is certified according to the Machinery Directive 2006/42/EC, which includes the base platform for L x W (Length x Width) between 840 mm to 2520 mm. The eQart is certified and follows the following standards:

- Machinery Directive 2006/42/EC Annex I
- EN1175-1:1998+A1:2010
- EN ISO 12100:2010
- EN ISO 13849-1:2015
- EN 1525:1998

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1.3 EN ISO 12100: Risk Assessment

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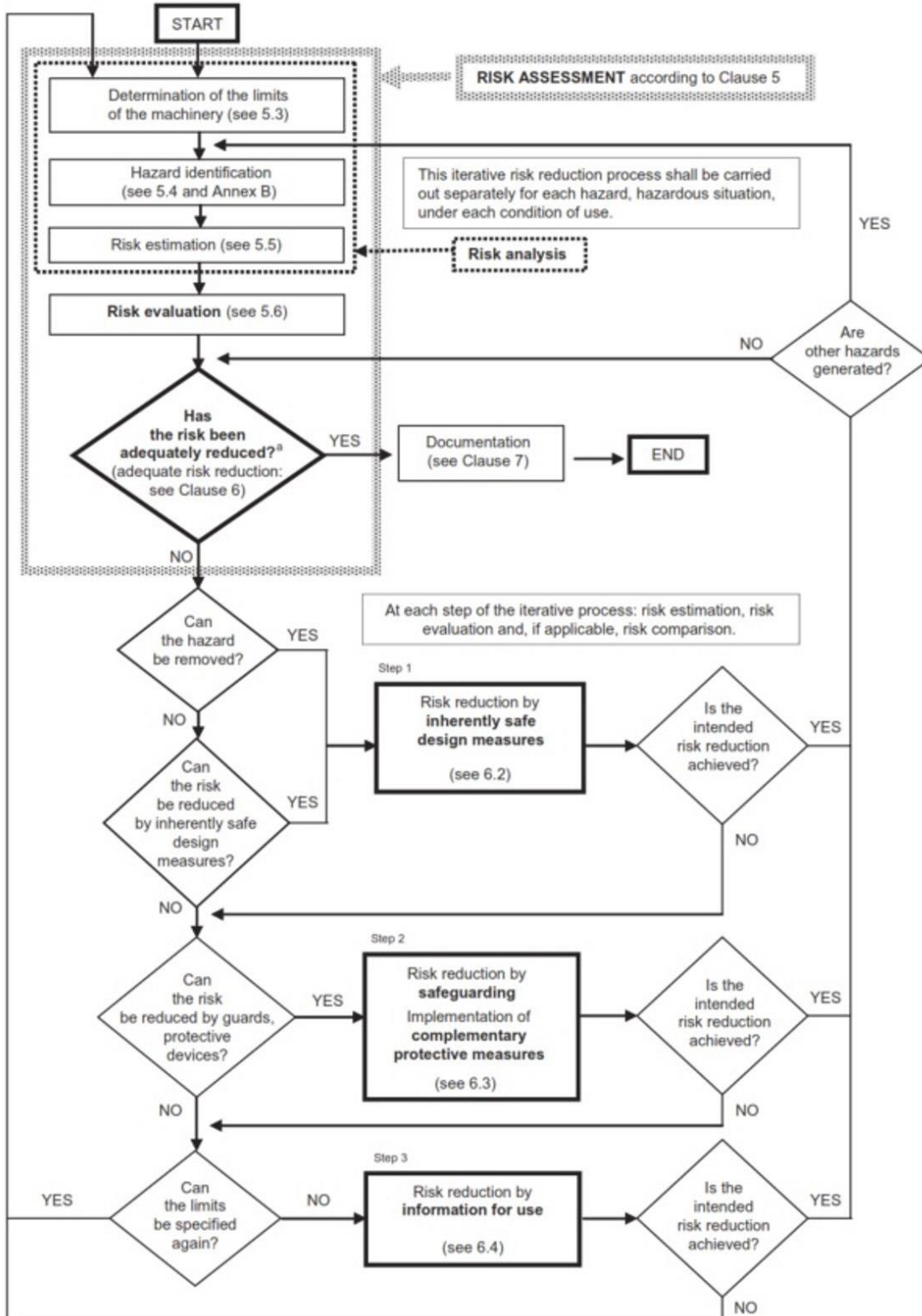
2 Determination of the limits of the machinery

2.1 Intended use

The eQart is intended to be used:

- Only indoors in an industrial environment.
- On even surfaces with concrete or painted floors.
- Not in slopes more than 1%.
- In areas with limited access for the public.
- Only with approved top structures design by FlexQube that is part of the complete eQart solution.
- No staircases in the immediate proximity of the eQart.

2.2 Inappropriate operation

To operate the eQart safely do not:

- Use the eQart for transporting people may cause the risk of serious injury.
- Use the eQart outdoors as it may cause damage to hardware and cause risk of personal injury.
- Tow other trolleys that have not been evaluated and approved by FlexQube.
- Overload the eQart with weight above its payload capacity as it may cause reduced performance, falling load, and instability of the eQart.
- Transport any corrosive, flammable, or explosive substances on the eQart.
- Control the eQart in manual mode from a long distance where the operator does not have a full view of the situation.
- Drive the eQart fast in manual mode close to objects and people can cause serious injury and damage.
- Use the eQart by people that are not properly trained to use it.
- Use it without performing a risk evaluation of the full use scenario for normal operation.

2.3 Assumptions

- The eQart size is within its certification limitations in terms of size spanning from a minimum of 840 x 840 mm to 2520 x 2520 mm.
- The load that the eQart is carrying is limited to 1000 kg (2200 Lbs.) and correctly placed on top of the eQart.
- The top structure of the eQart requires manual loading or unloading.
- The eQart is operating according to the Intended use parameters stated.

2.4 Risk assessment of the complete application

The user of the eQart is responsible for making a risk analysis of the complete use scenario and process in each case of implementation related to the user's facility. Examples of risks to consider are route planning, crossing traffic, safe loading and unloading of the eQart, etc.

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3 Safety functions

The eQart is equipped with several safety systems to protect people, buildings, and equipment.

3.1 Laser scanner collision avoidance

The eQart is equipped with 2 x Safety lasers scanners from Hokuyo to avoid collisions with humans and objects. The collision avoidance system is divided into 3 different zones.

- **Slow down zone**
  When a person or object enters this zone the eQart is slowing down to 0.2 meters/second to increase safety.
- **Stop zone**
  When a person or object enters the stop zone the eQart stops and will remain still until the object or person is removed from the zone. the eQart will beep and restart after 3 seconds.
- **Protection zone**
  The slowdown and stop function will in most cases avoid the activation of the protection system. If a person or object still ends up in the protection zone of the eQart the protection safety function will be activated. This function is directly connected to the actuators of the eQart through a safety relay. When the

270°
Sensor area

270°
Sensor area

Corner Module with Laser scanners

Corner Module w/o Laser scanners

Protection Zone

Warning Zone 1

Warning Zone 2

Corner Module with Laser scanners

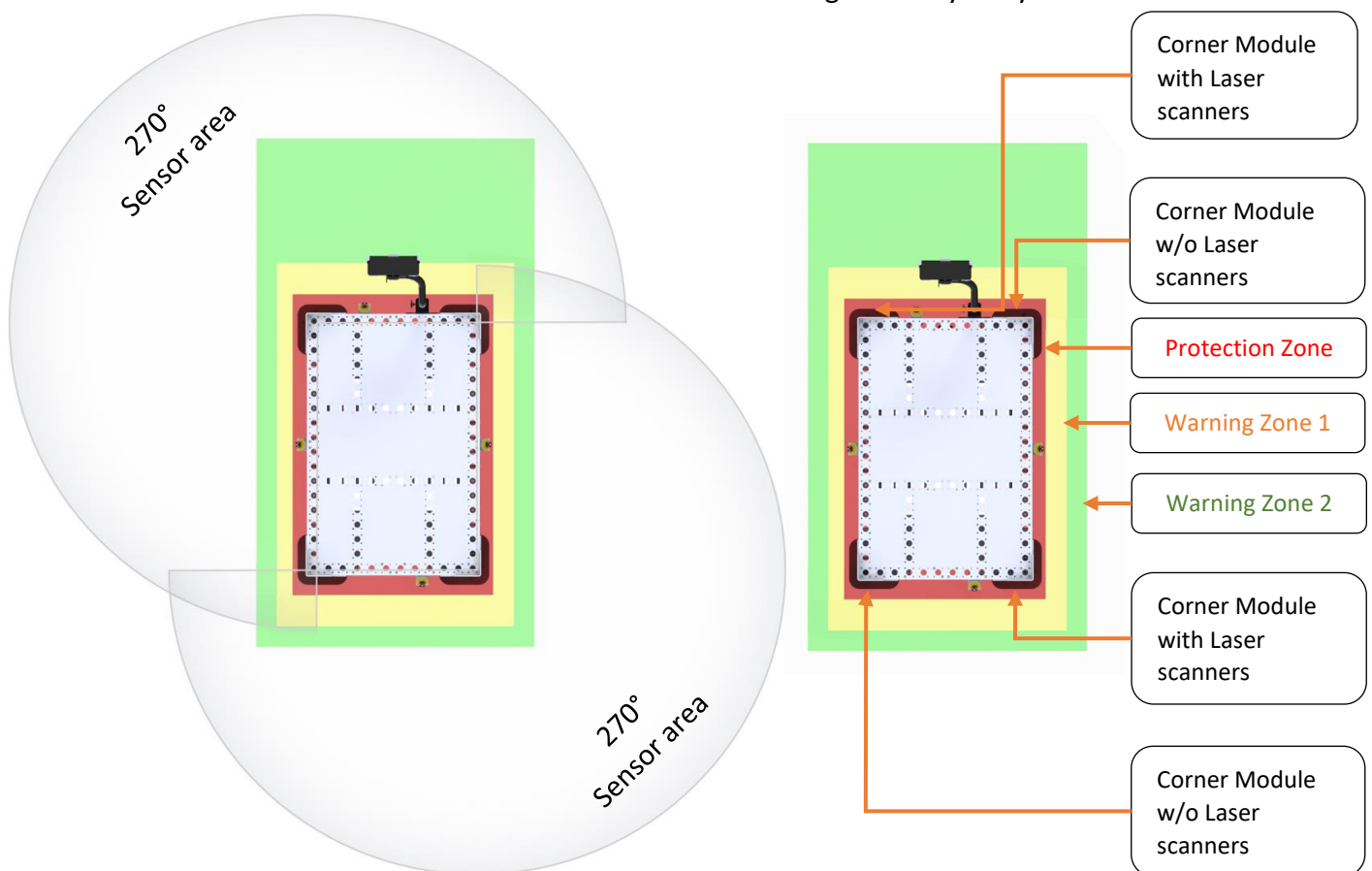Corner Module w/o Laser scanners

Figure 1 eQart laser scanner placement and safety zones.

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protection zone has activated the power to the motors is cut off, and the brakes will be immediately activated to stop the eQart safely. Activation of the protection zone must be reset in the cockpit before eQart can continue the operation.

3.2 Emergency stops

The eQart is equipped with 4 x emergency stops placed on each of the 4 sides. When the emergency stop has activated the power to the motors is cut off, and the brakes will be immediately activated. Activation of the protection must be reset in the cockpit before eQart can continue the operation.

3.3 Fail-safe motors

In case of power loss, the eQart breaks are activated eQart motors are braked to avoid unintended motion of the eQart. The brakes can only be released by the activation of power. Activation of emergency stops must be reset in the cockpit before eQart can continue the operation.

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4 Risk identification

ID	Function	Use Cases	Risks
1	Line follow driving	An object placed in traveling path	No residual risk
		An object moving into the travel path	Potential Hazard
2	Pick-up of Load	Load falls off	Potential Hazard
3	Transporting load	Load falls off	Potential Hazard
		Object placed in traveling path	No residual risk
		An object moving into the travel path	Potential Hazard
4	Drop-off of Load	Load falls off	Potential Hazard
5	Manual driving	Collision with objects	Potential Hazard
6	Line Follow failure	Loose visuals of line	No residual risk
7	Cockpit Connection	Loose WIFI connection between Cockpit and eQart	No residual risk
8	Settings	Wrong settings on eQart	No residual risk
9	Mapping	Faulty map recording	No residual risk

5 Risk Estimation & Evaluation

5.1 Line follow

When the eQart is transporting a load in the autonomous line follow mode it is using its laser scanner collision avoidance system to detect any objects in its travel path.

5.1.1 Object placed in traveling path - Residual risk

If a stationary object is placed in the travel path of the eQart the laser scanner will detect it and slow down and stop before a collision.

Conclusion: No residual risk.

5.1.2 An object moving into the travel path - Residual risk

If a moving object like a person or forklift moves into the travel path of the eQart or the side or back of the eQart the laser sensors will detect it and stop with a 360 field of view.
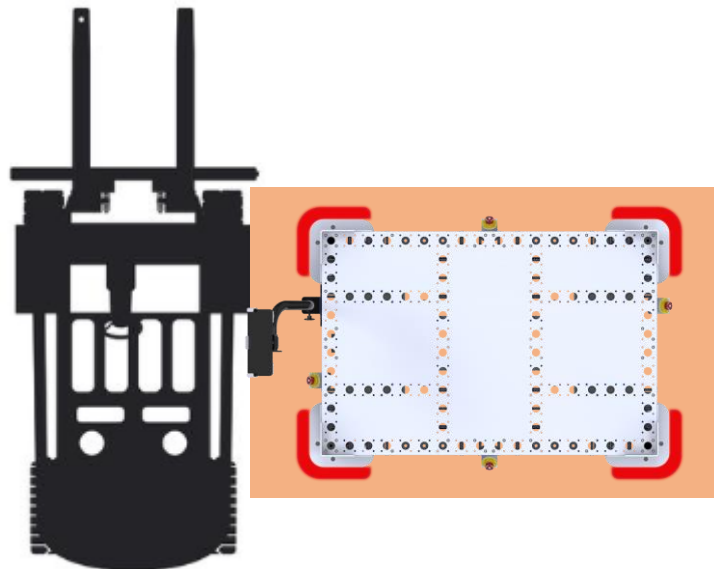

Figure 2 eQart laser scanners detect a forklift inside the safet zones.

However, because the eQart will only make an emergency stop a collision can appear it the person or forklift continues to move into the eQart.

This can result in:

- Potential collision with persons or forklifts.
- Potential effects can be human injury and damages equipment for both eQart and forklift.

However, persons and forklift drivers operating close to the eQart should be educated and aware of the movement of autonomous vehicles operating.

Conclusion: Residual risk very low.

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5.2 **Pick-up load**

When the eQart is picking up the load it is assumed that the eQart is stationary and the load is placed on top by an operator using a forklift or by hand.

5.2.1 Residual risk

While stationary the eQart laser scanner is not active. But to get it moving it requires an action by the operator to send it away to another station or start a mission. An operator is safe to move around the eQart without risk.

Potential hazard appears when the operator loads the load on top of the eQart, this can result in:

- Potential pinching/ crushing between the load and eQart of unaware operators.
- Risk of placing unsecured loads outside pallet guides, high center of gravity, or incorrectly stacked load.

Potential effects can be human injury and/ or damaged goods

However, the operator is always responsible to act responsibly around the eQart and place and secure loads on top of the eQart.
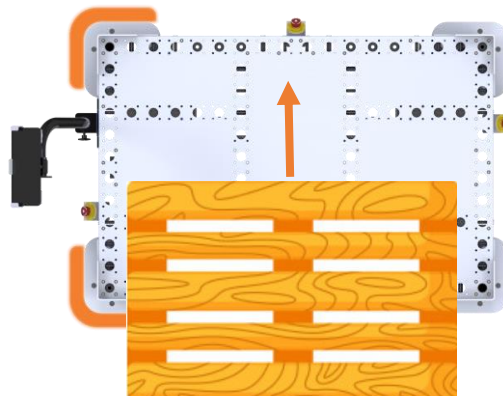
Conclusion: Residual risk very low

Figure 3 A load is placed on top of the eQart.

5.3 Transporting load

When the eQart is transporting a load in the autonomous line follow mode it is using its laser scanner collision avoidance system to detect any objects in its travel path.

5.3.1 The load falls off - Residual risk

If the eQart is transporting a load that is not properly secured or has a center of gravity too high there is a potential risk that the load can fall off.

A potential hazard appears when the eQart is turning or braking which makes the load fall off. This can result in:

- Potential pinching/ crushing between the load and eQart of unaware operators.
- Risk of placing unsecured loads outside pallet guides, high center of gravity, or incorrectly stacked load.
- Potential effects are human injury and/or damaged goods

However, the operator is always responsible to place and secure loads on top of the eQart.

Conclusion: Residual risk very low

5.3.2 Object placed in traveling path - Residual risk

If a stationary object is placed in the travel path of the eQart the laser scanner will detect it and slow down and stop before a collision.

Conclusion: No residual risk.

5.3.3 An object moving into the travel path - Residual risk

If a moving object like a person or forklift moves into the travel path of the eQart or the side or back of the eQart the laser sensors will detect it and stop with a 360 field of view.

However, because the eQart will only make an emergency stop a collision can appear it the person or forklift continues to move into the eQart.
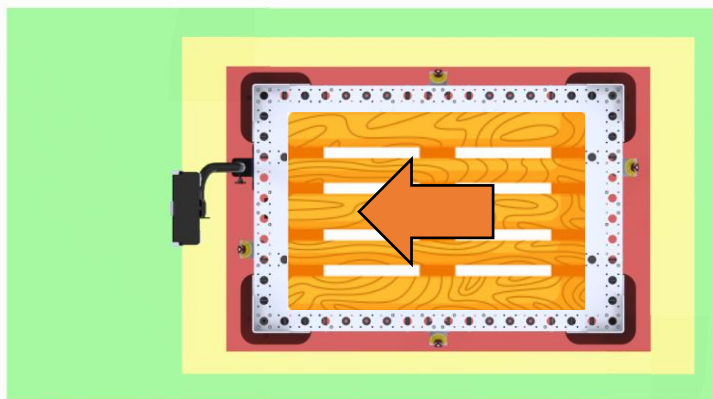

Figure 4 eQart transports a load with the laser scanners safety zones active.

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This can result in:

- Potential collision with persons or forklifts.
- Potential effects can be human injury and damages equipment for both eQart and forklift.

However, persons and forklift drivers operating close to the eQart should be educated and aware of the movement of autonomous vehicles operating.

Conclusion: Residual risk very low.

5.4 **Drop-off load**

When the eQart is dropping off the load it is assumed that the eQart is stationary and the load is removed by an operator using a forklift or by hand.

5.4.1 Residual risk

While stationary the eQart laser scanner is not active. But to get it moving it requires an action by the operator to send it away to another station or start a mission. An operator is safe to move around the eQart without risk.

Potential hazard appears when the operator picks up the load in an unsafe manner, this can result in:

- Potential pinching/ crushing between the load and eQart of unaware operators.
- The potential effect can be human injury and/ or damaged goods

However, the operator is always responsible to act responsibly around the eQart and remove the load from the eQart in a safe manner.

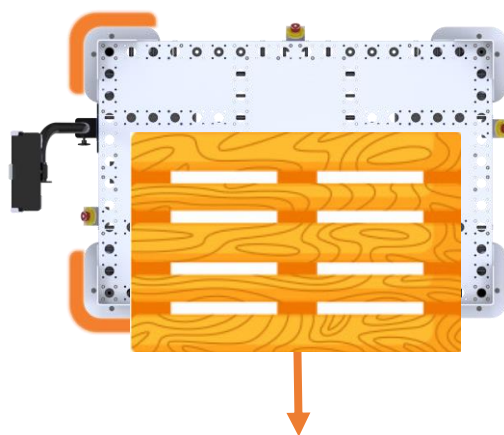**Conclusion**: Residual risk very low

Figure 5 A load is removed from the eQart.

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5.5 Manual driving

When driving the eQart manually using the eQart cockpit it will run at max 0,9 m/s using a narrow laser scanner field to prevent unintentional collisions.

5.5.1 Residual risk

Potential hazard appears if the operators drive the eQart into objects not detected by laser scanners or if a forklift etc. is running into the eQart.

This can result in:

- Potential collision with objects, persons, or forklifts.
- Potential effects can be human injury and damages equipment for both eQart and forklift.

However, when driving the eQart manually the operator is responsible to drive the eQart safely to avoid any collisions. It is always required that the operator have sight and control of the eQart.
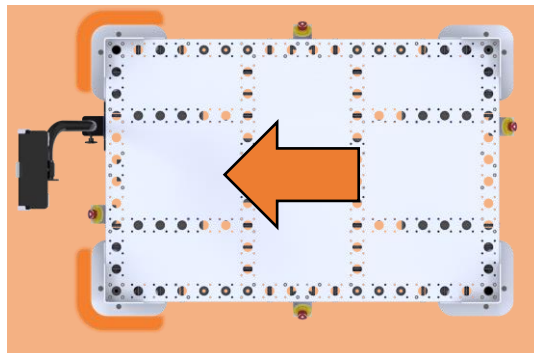
Conclusion: Residual risk very low.

Figure 6 eQart running in manual mode with smaller safety zones.

5.6 Line follow failure

If the eQart visual reading fails in line follow mode it will lose track of the travel path and automatically stop where it loses sight of the line.

The eQart will have its laser scanners active if it is moving when stopping it will alert operators with a beeping signal and remain stationary.

Conclusion: No residual risk.

5.7 Cockpit connection

If the eQart is out of range of the cockpit or the tablet loses the connection to the eQart it will not be able to control it.

A potential hazard appears if the operator needs to control the eQart but cannot send the commands.

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However, while driving in manual mode requires a constant connection to drive the eQart, if the connection is lost it will brake immediately.

If the eQart is in line follow mode it will continue its task until reaching its stop or the end of the line. If an object is placed on the line the laser scanners will detect it and brake before a collision. If an emergency appears, the operator can push the emergency brakes placed on all four sides to stop it immediately.

Conclusion: No residual risk.

5.8 **eQart Settings**

If the eQart is set to the wrong width in the settings the movement of the eQart might be impaired or erratic.

However, the laser scanner will still be active under both manual or line follow mode to prevent ant collisions. The operator will easily notice the behavior and be able to change settings or contact FlexQube support.

Conclusion: No residual risk

5.9 **Mapping**

The lines put down on the floor creates the line follow map that the eQart uses for navigation. But if this map is not done according to the mapping guidelines from the *eQart user manual* the eQart might not operate correctly.

If a junction is incomplete, or turns are to tight the eQart might run into issues both when recording the map and when operating in line follow mode.

However, in these scenarios, the eQart will still use its laser scanners to detect any objects in its travel path and will simply stop if it runs into a faulty map.

Conclusion: No residual risk.

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6   **Evaluate Application risk**

This risk evaluation is made with the assumption that the eQart top structure is passive requiring manual loading and unloading by operators or forklifts. This includes top structures like pallet guides, shelves, rollers, hangers, etc.

For any application where the transfer of the load is automated with the use of for example gravity rollers or any type of powered transfer system. For these applications, a risk analysis must be done considering the full process of the automatic transfer considering reliability and safety.

For a customer installation, the full process cycle needs to be considered by the purchaser to ensure that the eQart can move through the layout safely, stop at safe areas, etc. It is recommended to follow the guidelines in ISO 12100:2010 - Risk assessment and risk reduction, shown in this document in chapter 1.3. If any risks are identified they must be mitigated by changing the process, set up warnings, or educate personnel on-site.

The steps in the risk analysis according to ISO 12100 is:

- Define the limitations of the machinery
- Hazard identification
- Risk estimation
- Risk evaluation

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