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RESEARCH REPORT

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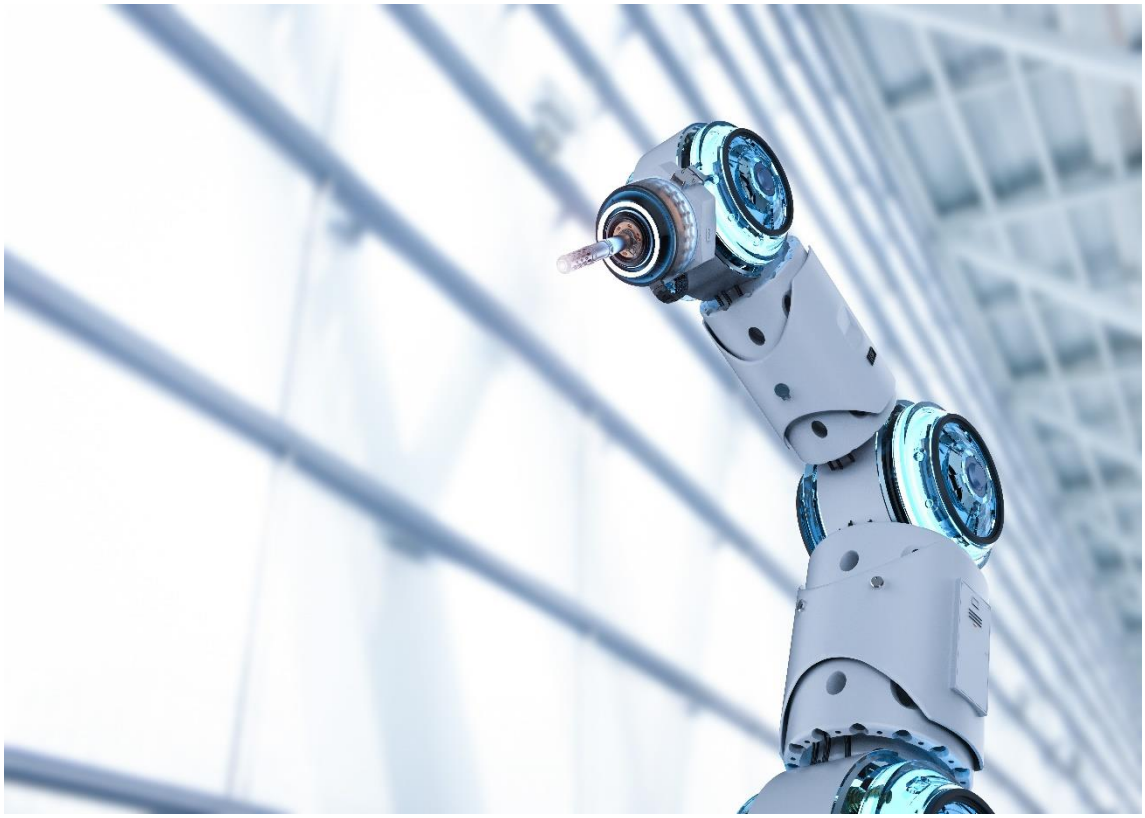

Location- and collision avoidance system technologies, providers and potential applications

Author: Antti Rantala

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Summary

The report examined what real time location systems (RTLS) and collision avoidance solutions are currently available in the markets. We also examined and evaluated different location and collision avoidance technologies. Further, this report identified in which kind of environments and application domains RTLS and collision avoidance systems could be applied.

As a result of this review, we identified many commercial location- and collision avoidance systems, which provide safety, efficiency and security for their users in various applications. The applications included factories, warehouses, construction sites, airports, malls, railway yards, defence forces, mines, healthcare, tunnels, museums, ports and other domains.

The most common technologies for location- and collision avoidance systems include Bluetooth, Wi-Fi, UWB (Ultra Wideband) and RFID (Radio Frequency Identification). In addition, GPS, advanced cameras, radars, computer vision and lasers were also utilized in different companies' solutions.

The market size of RTLS systems was 2.7 - 3 billion dollars in 2019, and it is expected to grow rapidly in coming years. The increase in automation, need for asset tracking and developed technologies are drivers that impact on the demand of the RTLS and collision avoidance systems. By 2025, 40% of new things connected to Internet will know their location, up from under 10% today (Gartner 2020).

Confidentiality	VTT Public

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Preface

This report is conducted as a part **Operational excellence and novel business concepts for autonomous logistic systems in ports (AUTOPORT)** - project. The key element in machine autonomy is adaptability to dynamically changing environment based on the available information. Currently automated cargo handling systems are designed for isolated areas but the demand is towards open operating environments and areas where there can be automated and manual operations at the same time. However, novel technologies and systems are needed to minimize safety hazards before such operations are possible. This report summarizes technologies that can be used to prevent collisions of people and machine in different environments. Also companies that provide collision avoidance and real time location systems are presented.

Tampere 17.2.2021

Authors

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1. Introduction

The development towards a higher automation level in logistics systems and the increasing automation level in the port operations is a clear global trend. Safe, secure and reliable automation solutions for ship-to-shore operation are crucial elements of the future transport systems.

Location- and collision avoidance systems are needed to secure safe and reliable logistics operations in the future. The location of people and things will be an increasingly important element of internal business operations. For example, robots and autonomous vehicles must all be location-aware because optimizing processes or improving safety require knowing the location of workers (Gartner 2020). This report presents various collision avoidance and location system technologies that could be used in port environment. Also, other application domains are presented.

This report is an overview of existing real-time location systems (RTLS) and collision avoidance solutions that are available on the market. The report highlights how the various technologies are applied and how the systems are utilised. Further, the objective is to identify, in which kind of environments and application domains such systems could possibly be used.

2. Market review

In the era of digitalization, tracking and monitoring assets and humans are becoming more common. Reasons to track assets and people include the needs to improve safety and security, and to optimize workflows.

This report focuses on companies that provide locating and monitoring solutions and services with different technologies. The information for this survey was gathered from company websites. The websites were found by assistance of other researchers and by simple Google searches. The key words used in the searches were “RTLS + (different industries)”, “Area control system + (different industries) and “Collision avoidance” + (different industries).

2.1 Potential applications for location- and collision avoidance systems

This chapter describes potential applications for location- and collision avoidance systems. First, potential outdoor applications are presented and then potential indoor applications. The classification to outdoor- and indoor applications is made, because different environments require different technologies. For example, variable weather conditions brings its challenges in outdoor applications. Also, the location system infrastructure may be harder to build outdoors.

Based on previous section and a review of different RTLS companies’ use cases, outdoor location services could be used e.g. in the following application domains:

- Ports
- Airports
- Outdoor warehouses
- Railway yards
- Construction sites
- Mines
- Tunnels

Gartner's (2020) report of indoor locating service market presents following application domains for RTLS indoor solutions:

- Enterprise offices
- Malls
- Retail stores
- Hospitals and healthcare facilities
- Manufacturers
- Warehouse/logistics
- Industrial environments
- Transportation hubs (airports, train stations)
- Museums
- University campus
- Hospitality (hotels, restaurants)

2.2 Companies that offer RTLS or collision avoidance systems

This chapter introduces companies that offer RTLS or collision avoidance systems. Companies are divided in three categories based on whether their solutions are applicable in outdoors only, both indoors and outdoors or indoors only. The categorization is made because different environments require different technologies.

2.2.1 Companies providing location- and collision avoidance systems for outdoor use

Ammo (https://ammo.co/) is an Australian company, which provides location systems to improve safety and operational efficiency. Their vision is to build & deploy safety solutions, incorporating advanced technologies to all industries at an international scale and pave the way for future automation. For example, they have developed an EMF based vehicle to personnel detection system for all work environments where vehicles and personnel are expected to work around one another.

Table 1. Ammo's location system offering

Technologies	Applications	Use cases and references
• RFID • UWB • Bluetooth • EMF (electromagnetic fields)	• Ports • Railways • Construction • Mining	• Port Brisbane (smart pinning station)

Navtechradar (https://navtechradar.com/solutions/oem-sensors/) is a British company that provides people and vehicle tracking and collision avoidance systems. They also provide intruder detection systems. Navtechradar's solutions are ideal for applications where other sensing technology may not be appropriate due to limited performance in adverse weather conditions.

Table 2. Navtechradar - people and vehicle tracking and collision avoidance systems

Technologies	Applications	Use cases and references
• Frequency modulated continuous wave (FMCW) Radar sensors • Smart Sensors	• Harbours and Ports • Mines • Industrial plants • Bridges • Airports • Industrial sites • Oil & Gas	• Port Botany (Radar sensors for straddle carrier navigation) • Port Pilbara (Radar sensors for conveyor belt loading) • Minas Gerais Mine, Brazil (Radar Sensors for Measurement and Collection) • Valencia Airport (Radar solution for automatic surveillance) • Mastrafjord tunnel, Norway (Automatic incident detection in tunnels)

Dotnetix (https://www.dotnetix.ai/scas-ai) is a South-African company that provides an intelligent on-board camera that helps to prevent collisions between machinery and pedestrians. The system analyses the potential of a collision with other objects and warns the driver. In the event that the driver does not respond, the Dotnetix system will stop the vehicle through communicating to the vehicle control electronics.

Table 3. Dotnetix - an intelligent on-board camera provider

Technologies	Applications	Use cases and references
• Deep Neural Network Technology with 3D image processing	• Mines • Ports • Industrial plants	

2.2.2 Companies providing location- and collision avoidance systems for both outdoor and indoor use

Zebra (https://www.zebra.com/us/en/products/location-technologies.html) is an American company which RTLS solutions deliver real-time visibility for assets and personnel indoors and outdoors. Their solutions automatically sense the location of assets and inventory, improves the safety of people and streamline production lines.

Table 4. Zebra - real-time visibility for assets and personnel indoors and outdoors

Technologies	Applications	Use cases and references
• UWB • RFID • Bluetooth	• Transportation • Manufacturing • Field Mobility • Warehouse Management	• Voestalpine, steel manufacturing: UWB and RDIF based system to prevent incidents and decrease rescue time • Washington Hospital Center: UWB-based RTLS system to improve understanding of the location and movement of people and assets and thus improve patient care • NYK Logistics: Advanced RDIF based system to improve the flow of goods and materials • US Air force: Asset visibility solution, material tracking with RDIF technology

Insoft (https://www.infsoft.com/use-cases) is a German company which provides tracking system for persons and objects. Solutions work seamlessly under the open sky in case the plant grounds are not uniformly covered by a roof. Company provides indoor digitalization, navigation, analytics and tracking services.

Table 5. Insoft - indoor digitalization, navigation, analytics and tracking services

Technologies	Applications	Use cases
• Wi-Fi • BLE • GPS • UWB • RFID	• Locating patients in hospital • Checking whether or not the hygiene rules have been followed in a hospital • Safety applications: Registering and locating employees in case of evacuation • Measuring visitor flows in shopping centres, airports, train stations, trade shows and events • Analysing walking routes for defining process optimizations • Locating forklifts, industrial trucks, robots and other work equipment • Locating mobile goods such as pallets, production parts and containers • Real time information on the dynamic locations of work equipment and goods incl. visualization on the site map • Locating mobile medical devices such as transportable x-ray equipment, hospital beds, gas canisters, etc. • Notifying the control system regarding the unauthorized movement of goods (anti-theft protection) • Analysing driving routes for defining process optimizations	• Vehicle and equipment monitoring at an airport • Navigation mobile app for employees and job candidates to find their way around a company site • Mobile services for External Maintenance companies – indoor navigation can help the technician to quickly find the defective elevator and obtain important status information • Indoor navigation and asset tracking in hospitals • A tracking solution to improve emergency management for operational forces • Cart and wheelchair tracking at an airport • Tracking routes in warehouses to reduce operational costs and the amount of time • Positioning of overhead cranes to improve safety and productivity when working with suspension and overhead cranes

RealTrac (https://real-trac.com/en/) is a Russian company which local positioning system is designed for localization and tracking people and objects outdoors and indoors, gathering statistics on movements, providing digital communication and data transmission. Their system prevents collisions of vehicles and people.

Table 6. RealTrack - outdoor and indoor local positioning system

Technologies	Applications	Use cases and references
• Bluetooth (BLE) • Industrial Wi-Fi • UWB • GNSS/ GPS/ GLONASS /BeiDou/ Galileo/ IRNSS	• Underground mining • Open cast mining • Manufacturing and processing • Logistics centres and warehouses • Healthcare institutions • Petroleum and gas industries • Transport industry (e.g. subway, land transport, parking)	• >12 mines (including: Polysaevskaya, South mine, Badran) • Samsung's warehouse

Eliko (https://www.eliko.ee/) is an Estonian software and electronics company, which provides various RTLS solutions.

Table 7. Eliko's RTLS offering

Technologies	Applications	Use cases and references
• RFID • UWB	• Logistics • Warehouses • Healthcare • Manufacturing	

Ubiquicom (http://www.ubiquicom.com/en/) is an Italian company which helps its clients to improve their process management by using RTLS solutions that are innovative and reliable. As a 'vendor-agnostic' company, Ubiquicom helps its clients to choose the best technological options in terms of performance and reliability.

Table 8. Ubiquicom's RTLS offering

Technologies	Applications	Use cases and references
• Bluetooth • UWB	• Logistics • Warehouses • Manufacturing • Healthcare	

Favendo (https://www.favendo.com/) is a German company which provides RTLS for mobile indoor positioning, wayfinding, people & asset tracking and proximity alerting on Bluetooth basis.

Table 9. Facendo's RTLS offering

Technologies	Applications	Use cases and references
• Wi-Fi • Bluetooth • GPS	• Manufacturing • Transportation • Campus • Shopping Malls • Mining • Oil&Gas	• Frankfurt Airport (Mobile wayfinding and proximity messaging) • Volkswagen IT City – Indoor/outdoor positioning and mobile wayfinding • Audi (Car tracking and wayfinding) • Hammerson plc (Mobile wayfinding, proximity messaging and infrastructure maintenance)

Abeeway (https://www.abeeway.com/) is a French company, which provides efficient management of assets, people protecting and animal monitoring through location intelligence. Their solution works both outdoors & indoors.

Table 10. Abeeway's RTLS offering

Technologies	Applications	Use cases and references
• Bluetooth • Wi-Fi	• Transportation & Logistics • Construction • Airports • Ports • Warehouses • Farming	• Urban train in Paris (To determine where the construction machines are located in the tunnel)

Overdrive (https://overdriveiot.com/) is a Singaporean Company which RTLS solutions track the precise locations of people and objects within buildings, facilities or compounds – in both indoor and outdoor areas.

Table 11. Overdrive's RTLS offering

Technologies	Applications	Use cases and references
• Wi-Fi • Bluetooth	• Factories • Warehouses • Hospitals	

Ubisense (https://ubisense.com/) is an American company which provides UWB based RTLS solutions for various industries.

Table 12. Ubisense's RTLS offering

Technologies	Applications	Use cases and references
• UWB	• Factories • Warehouses • Transportation • Healthcare	• BMW car assembly plant in Regensburg • Aston Martin plant in Gaydon, UK

Ameol (https://www.ameol.it/en/egopro-safety/) is an Italian microwave engineering company that provides variety of collision avoidance and safety solutions. They offer for example collision avoidance systems for mobile working machine, and solutions for crossing sections in warehouses/factories. They also provide control of the position and number of people within the various zones.

Table 13. Ameol - collision avoidance and safety solutions

Technologies	Applications	Use cases and references
• RFID tags • Sensors • CCTV Cameras • RADAR technology	• Warehouses • Factories • Tunnels	• Enel Green Power (System to control access on site, area boundary control system) • Sofidel SPA (Warning proximity and alert system)

Fidera Oy (https://fidera.fi/) is a Finnish company that provides automated monitoring system based on sensors and cameras. Their offering is divided in three sections: personnel tracking, equipment tracking and video monitoring.

Table 14. Fidera - automated monitoring system

Technologies	Applications	Use cases and references
• RFID sensors • BLE • Cameras	• Personnel tracking • Access control • Work time monitoring • Contractor's obligations • Asset tracking • Warehouse inventory • Video monitoring • Security services	• Länsimetro construction site (personnel monitoring, asset tracking) • S-Market Porvoo (Reducing customer lines and waiting times, efficient product placement)

Sick (www.sick.com) is a German Laser company that has developed AOS Prime[1] collision avoidance system for outdoor robots. The system is laser-based but it can be expanded with RFID, GPS, and other types of sensors to enable vehicle identification when automated guided vehicles are in use.

Table 15. Sick - AOS Prime collision avoidance system for outdoor robots

Technologies	Applications	Use cases and references
• Lasers	• Collision avoidance for automated working machines (for example cranes in ports)	

Tagvance (https://www.tagvance.com/port-index) is a Singaporean Start-up company that provides high accuracy tracking and monitoring solutions that allow businesses to determine in real time and with high precision the location of people and assets in industrial spaces. They build solutions to track personnel and assets in indoor/outdoor and confined environments. They provide very little information about their technology and applications on their website However, they collaborate with Quuppa and utilize their solutions.

Table 16. Tagvance - high accuracy tracking and monitoring solutions

Technologies	Applications	Use cases and references
• Bluetooth	• Ports • Mining	

IBM (www.ibm.com) Guardian Angel[2] product offers wearable wireless sensors for employees to monitoring and improving safety. This solution is only for employee tracking, not for vehicles.

Table 17. IBM Guardian Angel – for people tracking

Technologies	Applications	Use cases and references
• Wearable wireless sensors	• employee tracking	

2.2.3 Companies providing location- and collision avoidance systems for indoors use

Quuppa (https://quuppa.com/industry-4-0/ is a Finnish company whose RLTS solutions improve safety and increase operational efficiency. The system can prevent collisions between workers and machinery by alerting workers to likely collisions calculated by using real-time route information. The same system can also alert workers to the fact that they are entering a danger zone. They are focused on indoor location systems.

Table 18. Quuppa's RTLS offering

Technologies	Applications	Use cases and references
• Bluetooth • Wi-Fi • Advanced antennas and tags	• Warehouses • Mining • Factories • Healthcare • Smart buildings	• Empower (RTLS for people and machinery for collision avoidance and tracking in a factory) • Morita Fire truck factory (Asset tracking) • Mizkan Museum (App based tour guide) • Fujitsu warehouse (visualizations of workflows)

[1] see details for AOS Prime Object detection System in https://www.sick.com/media/docs/9/49/649/Product_information_AOS_Prime_Object_detection_systems_en_IM0053649.PDF

[2] see details for Quardian Angel in www.ibm.com https://www.ibm.com/us-en/marketplace/iot-safer-workplace/resources

Sewio (www.sewio.net) is a Czechish company that provides UWB-based RTLS system for locating people and assets. System also enables warehouse route optimization and other solutions that boost efficiency.

Table 19. Sewio's RTLS offering

Technologies	Applications	Use cases and references
• UWB	• Warehouses • Mining • Manufacturing • Sports	• Budweiser Budvar Brewery (Replacing RFID-Powered Forklift Tracking with Sewio's UWB-based RTLS system to cut down maintenance costs) • SEG Automotive (Shortening lead time and reducing labour costs by leveraging indoor tracking RTLS) • Volkswagen (Digitization in automotive industry by leveraging RTLS and digital twin)

Vero Solutions (https://vero.solutions/warehouse-real-time-location-systems/) is a British company that provides a real time location system for collision avoidance, people tracking and equipment tracking. Their solutions provide for example safety, quality management and inventory management.

Table 20. Vero solutions' RTLS offering

Technologies	Applications	Use cases and references
• Wi-Fi • RFID • Cameras • Sensors	• Warehouses • Manufacturing • Retail • Healthcare	• London Fire Brigade (Tracking uniforms using RFID solution) • Heathrow airport (successful pilot project to track luggage trolleys)

Ciholas (https://www.ciholas.com/) provides custom engineering and RLTS product design services. Ciholas can develop various systems and products including:

- Real Time Location Services (RTLS) for inventory, people, livestock or machines
- Proximity and alert systems for safety, protection, security, and automation
- Precise navigation for autonomous vehicles and robots
- Virtual fencing, security, and monitoring

Table 21. Ciholas' RTLS offering

Technologies	Applications	Use cases and references
• Wi-Fi • Bluetooth • UWB	• Warehouses • Manufacturing • Mines • Museums	• The museum of Bible (visitor guide and visitor flow monitoring)

Accuware (www.accuware.com) is an American company which provides a visual 3D positioning/location system for indoor applications, based on Visual SLAM. SLAM is a technology which is able to build a map of an unknown environment and perform location, simultaneously leveraging the partially built map, using just computer vision.

Table 22. Accuware's RTLS offering

Technologies	Applications	Use cases and references
• Computer vision • Odometry • On-board camera	• Warehouses • Manufacturing	• Modani Furniture warehouse (Forklifts tracking)

HID Global (www.hidglobal.com) provides an indoor location solutions for asset management and building occupancy management. They offer Bluetooth –based location services.

Table 23. HID Global's RTLS offering

Technologies	Applications	Use cases and references
• Wi-Fi • Bluetooth	• Smart Buildings • Healthcare • Industrial environments	

Airista Flow (www.airistaflow.com) is an American company that provides indoor RLTS solutions. Assets and personnel can be located with 1- to 3-meter precision, at room or sub room level, depending on the use case.

Table 24. Airista Flow's RTLS offering

Technologies	Applications	Use cases and references
• Wi-Fi • Bluetooth • Infrared signals	• Healthcare • Manufacturing • Hospitality	• Wristbands for hotel housekeepers to get help in dangerous situations • The Lawrence Upper School (tags for students and staff to get instant help in emergencies) • Over 200 hospitals and 500 healthcare providers (location services for staff and equipment management, operating room efficiency)

The Cisco Hyperlocation (www.cisco.com) solution offers hardware and software innovation that can deliver 1-to 3-meter location accuracy on average for associated Wi-Fi clients.

Table 25. Cisco's RTLS offering

Technologies	Applications	Use cases and references
• Wi-Fi • Bluetooth	• Retail • Healthcare • Hospitality • Airports	

HERE (www.here.com) is a company, which offers outdoor and indoor location services. HERE Tampere department develops indoor RTLS using UWB and other technologies.

Table 26. Here's RTLS offering

Technologies	Applications	Use cases and references
• Wi-Fi • Bluetooth • UWB	• Buildings	

IIwari is a Finnish location service company, which provides indoor RTLS services in various industries.

Table 27. Iiwari's RTLS offering

Technologies	Applications	Use cases and references
• UWB	• Retail • Offices • Healthcare	

3. Results

There are many commercial location- and collision avoidance systems, which provide safety, efficiency and security for their users. Finnish companies in this sector include Quuppa, Iiwari and Fidera. Table 28 compares different RTLS technologies and Table 29 lists different RTLS and collision avoidance system applications and solutions.

Table 28. Comparison of different RTLS technologies (modified from Sewio's webpage 2020).

Technology	Accuracy	Power consumption	Range (m)	Disadvantages
UWB	cm-dm	Low	1-50	Signals can be blocked by large metallic objects
Wi-Fi	m	High	1-50	Use of ISM band - interference
Bluetooth	m	Low	1-20	Use of ISM band – interference, low range
RFID	dm-m	Low	1-50	Low range and small coverage, unsecure communication
Laser	mm	High	1-5	Requires direct Line of Sight, provides only relative positioning
Infrared	m	Low	1-5	Requires direct Line of Sight, can be easily blocked by opaque objects
Camera	mm-dm	High	1-10	Requires big computing power, requires Line of Sight
GPS	m	Low	-	Works only in outdoors. May be inaccurate

Table 29. Examples of real time location system (RTLS) and collision avoidance system applications and solutions

Applications	Solutions in the markets
Maintenance operations	Overdrive's Wi-Fi- and Bluetooth based RTLS system
Large construction projects	Fidera's monitoring and tracking system Ammo's crane personnel RTLS
Airports	Insoft's Vehicle monitoring system Navtechradar's Radar solution for automatic surveillance
Malls	HID global' s smart buildings solutions Favendo's Mobile wayfinding, proximity messaging and infrastructure maintenance
Railway yards	Ammo's Track Maintenance personnel detection system
Defence forces	Navtechradar 's intruder detection system Zebra's material tracking with RDIF technology
Mining sites	Real Trac's RTLS for mining Navtechradar's Radar sensors for measurement and collection
Healthcare	Zebra's RTLS for people and assets Eliko's UWB based RTLS Ubiquicom's healthcare solutions
Manufacturing	Zebra's system to prevent incidents and decrease rescue time Ubisense's RTLS system for BMW car assembly Real Trac's RTLS Eliko RTLS
Warehouses	Insoft's Route tracking Real track's RTLS Eliko's RTLS
Tunnels	Navtechradar's Automatic incident detection in tunnels
Museums	Quuppa's App based tour guide Ciholas's tour guide and people tracking solution
Ports	Navtechradar, radar sensors for straddle carriers Ammo's smart pinning station in Port Brisbane

The most common technologies for location- and collision avoidance systems were Bluetooth, Wi-Fi, UWB and RDIF. In addition, GPS, advanced cameras, radars, computer vision and lasers were utilized in some companies' solutions.

4. Summary

Collision avoidance and Real-time location systems provide safety, efficiency and security for various applications such as manufacturing, logistics, hospitality and healthcare. RTLS and collision avoidance technologies can be used to prevent accidents in environments where vehicles and people are expected to be next to each other.

Bluetooth, UWB and Wi-Fi are the most common technologies that are used in indoor RTLS solutions. In addition, GPS can be used outside, although it may be inaccurate. Also, radar- and laser technologies can be used in outside collision avoidance systems. Every technology have their advantages and disadvantages, and it should be analysed case by case which technology is the most suitable. The reliability of the solution can be increased by combining different technologies.

The market size of RTLS systems was 2.7 - 3 billion dollars in 2019 (MarketWatch 2020), and it is expected to grow rapidly in coming years. The increase in automation, need for asset tracking and developed technologies are drivers that impact on the demand of the RTLS and collision avoidance systems. By 2025, 40% of new “things” connected to internet will know their location, up from under 10% today (Gartner 2020).

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