BEUMERGROUP

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MODERN INDIVIDUAL CARRIER SYSTEMS FOR AIRPORT BAGGAGE HANDLING

› The definition of an ICS system and how to choose and apply an ICS type to specific airport requirements.

AIRPORT
WHITE PAPER

INTRODUCTION

An essential component in today's airport baggage handling is the use of a modern baggage handling system that provides an efficient and flexible operation for the airport, airlines and airport authorities. This whitepaper explains the term Individual Carrier System (ICS) which includes cart or tote-based baggage handling systems and explores the benefits that these systems have to offer.

DEFINITION OF ICS SYSTEM

Individual Carrier Systems (ICS) are designed to transport bags in carriers at high speeds over long distances and there are a number of ICS available on the market. This type of baggage handling system (BHS) is still relatively new to the airport market and there is some confusion as to what an ICS really is and when it can be applied.

The primary purpose of a baggage handling system is to move bags from the check-in area through the screening process, manage bags stored in an Early Bag Storage system or other types of buffers or decoupling zones and transport them to the departure gate. A BHS is also utilised to move bags from one gate to another during transfers and move bags from the arrival gate to the baggage-claim area.

An ICS is generally characterised by the handling of baggage in an individual carrier (cart or tote - sometimes referred to as a tray). The ICS is based on the idea that loading a bag into a tote with defined characteristics eliminates several issues that occur when handling bags (also commonly referred to as proper bag placement/hygiene). The ICS utilises individual totes to carry a single bag. Bags travelling in a tote system reduces the probability of wheels, straps or odd shaped bags catching on the conveyor system and creating jams during transportation which inherently increases the positive tracking of the bag/tote. The ICS is specifically designed as a closed loop to allow standardised carriers to flow through the baggage system with precise tracking and predictability, at a higher speed than with conventional systems.

The ICS is modular in design and always runs in a loop, as opposed to the conventional one-way delivery system. Carts or totes circulate around the passive rail track loop and then return to the baggage loading points as and when necessary for moving baggage around. Some modern advanced tote systems can even run in reverse, providing self-healing routing options and additional redundancy solutions to critical baggage systems. This white paper only considers rail-based systems that fall under the category "high-speed baggage handling systems".

CART SYSTEM

In a cart system, each cart carries a single piece of luggage. The system consists of a cart with wheels with a container-like carrier on top. The cart travels on a track like a roller coaster with a speed of up to 10 m/s and stops to load and unload.

A 'DCV system' is also part of the cart system family. DCV is short for Destination Coded Vehicle which is an unmanned cart which can load and unload bags.

Its job is to move the bag quickly to an off-ramp at the gate. It carries an onboard computer that broadcasts a unique number identifying that particular cart. Once a bag is loaded, the bag ID is "married" to the ID, of the cart. Carts are tracked through the system via a special positioning system. The bag stays in the cart until it is discharged for Hold Baggage Screening (HBS) after which it is reloaded into the cart and married to the cart ID which it stays with until its assigned make-up carousel for collection.

TYPICAL CART SYSTEM SPEED:

- 10 m/s (32.8 ft/sec)

CAPACITY:

- Loading/unloading: 2,400 bags/h

The cart system from BEUMER Group is the autover® system on which intelligent carts, called autoca®, run in a rail system. To route the carts, data from scanners is transmitted to a computer that translates it by using a lookup table to match the

flight number with the appropriate chute. The control system guides the cart to its destination by communicating with the cart's onboard controls system. The cart system features a contactless power transmission device, a drive system and an on-board computer for routing, distance and loading control. The cart system steering is handled by a pivot arm deployed as needed to change direction in the system.

There are no moving elements in the rail system. The system has contactless energy and data supply where the energy is transferred contactless according to the transformer principle and results in no wearing parts and high efficiency. The data communication with the cart is transmitted with Wi-Fi technology and again there are no wearing parts to replace and the technology provides total control of the cart at all times. Investment in capacity increase can be realised on demand in the future by adding additional carts.

System maintenance can be done during normal operation by calling carts into a designated service station.

TOTE SYSTEM

A tote system is, like the cart system, one bag per tote and one tote per logical section in the system. It is the simplest and most secure technology to control the individual bag.

Once a bag is loaded in a tote, the bag ID is married to the ID of the tote. Totes are transported and tracked through the conveyor-like system via RFID tags embedded in the tote and RFID readers placed throughout the baggage system. The bag stays in the tote until it is discharged at its assigned make-up carousel.

A term "tray system" is basically the same as a tote system and the description really depends on the name chosen by the manufacturer. The term "tray system", however, should not be confused with the terms "tilt-tray" system (which is a loop-sorter based technology also used as baggage handling technology), nor with the "tub-tray" system (which is the auxiliary tray system used at check-in in which to place odd sized bags before entering them into the baggage handling system).

The tote system from the BEUMER Group's range of Crisplant airport products is the CrisBag®. In this system, bags are loaded into the tote after check-in, and stay in the same tote during transport, screening, storage and sorting to be discharged at gate only. Arrival bags can be handled in the same system.

The tote system is a modular concept with a wide range of standard modules and components for flexible configuration. Each system is tailor-made for the airport's individual requirements and the modularity offers a powerful scaling ability for growing airport operations. The bag and carrier are not separated until the final destination is reached and the individual control of each tote ensures 100% safe tracking data with live track and trace capability at any time.

Every system element follows the same principle: one bag in one tote, one tote on each individual VFD-controlled module. Every motor has a dedicated variable frequency drive (VFD) and every VFD has one sensor. The overall system controls the sort destinations, empty tote management, etc., with Ethernet (LAN technology) linking all decentralised control modules. The route calculation in the sorter controls ensures minimum transport time and optimises load balancing.

TYPICAL TOTE SYSTEM SPEED:

- Recommended high speeds in the range of 7 m/s (23 ft/sec) for operational efficiency
- Infinite speed adjustment, due to VFDs

CAPACITY:

- Tote top-loader, 1,800 bags/h
- Dynamic discharge, 3,000 totes/h

WHY IS ICS TECHNOLOGY SO IMPORTANT TO AIRPORTS?

Tracking
Tote- and cart-based baggage handling systems can deliver 100% track and trace because as soon as a bag is placed in a tote or cart after check-in, all the information in the IATA

barcode on the baggage tag is married with the carrier, which is then used to easily track the tote or cart throughout the system. The bag and carrier are not separated until the final destination is reached.

Tote and cart systems provide unique traceability of bags with RF readers built into the tote track at critical decision points such as divert or merger locations, so it is simple to re-verify the bag tag and data prior to each decision point ensuring the best tracking solution available for a baggage system.

The systems offer the ability to re-route a bag post screening if there is a remote decision made to change the status of a given bag during its journey through the baggage handling system.

Tote and cart systems combine very high-speed transport with special carriers which enable 100% track and trace throughout the baggage handling process including during Hold Baggage Screening (HBS) and in the Early Baggage Storage (EBS) system. EBS allow passenger bags to be checked in hours before flight time with the flexibility of retrieving bags automatically at any time prior to reaching their final destination. The EBS system can shave the baggage system peaks by releasing bags into the system during low volume time periods, minimising the risk of baggage missing the connecting flight and also allowing baggage to be easily removed from the system if a passenger fails to board the connecting flight.

Security screening and load sharing

Today's demand for security is only met if you have 100% track and trace in the BHS. Modern ICS offer exceptional high load sharing of Hold Baggage Screening machines, a flexible matrix design and fast transport and connection between screening areas. This makes it possible for the airport to live up to these security demands without creating bottlenecks in screening due to insufficient staffing or resources. By maintaining automatic screening the airport also maintains 100% track and trace.

Airlines have become much more driven by the wish to track baggage and provide this as a passenger service. The IATA Resolution 753 is also a driver. This sort of track and trace can of course be facilitated by the use of conventional conveyor technology, i.e. by tagging with RFID, but no track and trace technology is higher than the accuracy provided by ICS technology.

In many regions airports are now migrating to a common-use model. This allows airlines to share the cost of using a single system operated by a BHS operator. It of course provides a more efficient operation for the airport, greater flexibility for the airlines and a consolidated security checkpoint for compliance with security regulations, but it also requires a well-designed system that can guarantee secure sortation of bags from a number of airlines, handled by a number of operators in one and the same system.

Choosing the right ICS system design will mean a fast and easy baggage flow management solution where the hold baggage screening area can cope with the maximum throughput capacity of the baggage handling system. With the hold baggage screening being an integral part of the baggage handling process, the system has to be designed to balance loads between redundant routes, which will ensure optimum usage of available Explosive Detection System (EDS) resources to keep the number of screening machines to a minimum.

Upstream, the system has to balance the baggage load to avoid backlog in the check-in areas. Baggage congestion really has a negative effect on the passenger check-in experience if passengers leave the area without seeing their baggage enter the baggage handling system. Downstream, the baggage handling system also takes into consideration how to avoid bottlenecks towards and between the Explosive Detection System lines. (EDS automatically detect explosive material concealed inside hold baggage and cargo.) The baggage handling system controls will determine the optimal route to destination while baggage is already on its way through the system. This type of "on-the-fly" destination determination will ensure each bag is cleared immediately into the baggage handling system. (This is to reduce the risk of delayed baggage and a subsequent negative airline and passenger experience.) In some solutions a further redundancy feature lies in the system's ability to reverse totes to find an alternative route should this be necessary.

Early baggage storage (EBS)

There are a number of solutions for handling early baggage in the baggage handling system. Depending on the system size and airport requirements, the ICS can offer various solutions for holding the baggage until called for make-up.

EBS - tote system

The bags which arrive from check-in remain in their assigned totes from check-in to make-up – also as they are held in the Early Bag Storage (EBS). The ground handling operator

enters the number of the departing flight into the sort controller and the BHS control system identifies and retrieves the bags for that flight and transports them from the EBS to the lane for loading. Bags which have been checked-in closer to the flight departure can be flagged up as a priority to the centralised security section and called directly to the queuing lane as soon as they clear security. The ability to identify and prioritise bags which are required for imminent departures means that a higher percentage of bags will be successfully loaded onto the correct flight. The tote system offers the opportunity for line-based storage systems with high flow capacity and for very cost-efficient, rack-based storage solutions with single bag access.

EBS - cart system
The cart system either integrates with a conventional system for EBS, on which bags are stored in lanes until ready for make-up, or alternatively, the bags remain in their assigned carts from screening-in to make-up (carts cannot be transported through a screening machine).

WHAT MATTERS WHEN DECIDING BETWEEN A CONVENTIONAL SYSTEM OR ICS FOR BAGGAGE HANDLING

The requirement by the airport must be a system that can handle the necessary baggage volume, faster and with better value, and ideally be more energy-efficient than the airport's existing system. In addition to offering operational baggage handling improvements, some modern ICS technologies are known to deliver real environmental benefits with leading-edge technology that offers 60% in energy savings.

Another requirement for ICS technology is to enable fast connections for example in tunnels. These are most often driven by a key priority to handle fast transfer connection times, which is essential to support most airports' continued growth as international air-traffic hubs. (Hubs are airports that serve as a central connecting point through which many flights are directed.)

The system must ensure the baggage connection time between terminals is kept to a minimum to allow each item of baggage to be processed and allocated to the correct make-up position. In some airports it may involve a short walk to the passenger terminal, while in others it could involve a longer distance and a train journey. An ICS solution can provide bag transportation more than 500% faster than a conventional conveyor belt system.

Another requirement is low operations and maintenance costs. Many factors determine the operations and maintenance costs of the BHS, including run time, the number of system jams and the required number of spare parts. As an example, based on experience gained from operating systems using both technologies, a conventional system bag jam rate is typically 1.5% - 2% of bags processed and for an ICS, it is less than 0.1% of bags processed.

Also there is very little maintenance and very low spare part consumption associated with ICS systems. For the ICS, the main driver for spare parts is expected run time per element. The basis for such a calculation would typically be parts usage experience over the last 10 years in various ICS systems. The calculation of spare parts usage after 15 years is difficult to determine, but it is estimated that for the ICS, parts usage will increase by 10% and for the conventional system by 20%.

OPERATIONS AND MAINTENANCE COST SAVINGS PER YEAR FOR AN ICS SYSTEM (COMPARED TO CONVENTIONAL CONVEYOR TECHNOLOGY)

Operations staff	68% saving
Maintenance staff	33% saving
Spare parts	43% saving

The calculations above are based on hourly rates for operations and maintenance staff at an undisclosed airport in North America. The calculation for spare parts usage is based on approximately 9 million bags per year for both outbound and inbound systems. For the conventional system the parts usage is based on experience in US-based conventional systems.

Ideally the airport should be made aware of these calculations showing the costs for up to 15-20 years from the time of investment, including the return on investment time, in order to decide between the conventional and the ICS technology, as this depicts the costs of OPEX as well as the true long term cost of ownership. Included in these calculations would also be operations and maintenance staffing. The overall staffing plan should be predicated on the fulfillment of key service level criteria such as system availability greater than 99%, response times of no more than five minutes and a maximum allowed rate of short-shipped bags of five in 10,000. An example could look like this:

OPERATIONS AND MAINTENANCE STAFF PER SHIFT

	Conventional conveyor	ICS
O&M Manager (1 shift/day)	1	1
Shift Supervisor	1	1
Manual Encode/Porter	2	1
Control Room Operator	2	2
Maintenance Technicians	12	8
Baggage Operators	4	N/A

In the above example, the staffing required for the manual encoding station (MES) is assumed to be the same in both systems since the read rates on the Automatic Tag Reader (ATR) will be the same. However, the "lost in tracking" rate for the conventional system provides some additional throughput at the MES.

BENEFITS AND CONCLUSION

Today's stringent security criteria can only be met if the airport can provide 100% track and trace in the BHS. ICS has obvious benefits for larger airports, but has benefits for medium-sized airports as well.

ICS offers the ability to reduce mis-sorts which also means an improvement of the Left Behind Index (the mishandled baggage rate, LBI), also known as short-shipped baggage, which will influence internal targets and KPIs for performance values.

Cart technology

Cart technology is a very cost-attractive option for lower line capacities and is attractive for systems that have many loading/unloading positions. These include options and extensions because additional loading/unloading positions only need software configuration, not "loading/unloading" hardware. The system can also grow at a reasonably low cost, when the need for capacity increases, as more carts can simply be added.

- It allows for easy redundancy concepts, e.g. bi-directional lines in a tunnel
- It is very attractive for remote connections, e.g. car park check-in, centralised manual inspections, etc.
- It allows for secure transport and tracking in combination with screening on belt conveyor matrix
- Some cart systems can carry totes from other systems (including OOG totes) as well, thereby allowing for integration of different types of systems
- It has a low maintenance cost due to contactless energy and data supply and no motor/sensor in the rail system (a big advantage for tunnels)
- There is low energy consumption (for example, there is only movement of one autoca® if one bag needs to be transported). If a rail system is not needed in low peak times it will be switched off (intelligent power management).

In the cart system, the rail system is more or less maintenance free: no sensors, no motors, no moving parts - only the steel rail with a power and data cable. This makes the cart system attractive, especially for longer tunnel connection, because maintenance can be done on the carts during normal operating hours in a service location outside of the tunnel.

Tote technology

Tote technology is extremely energy-efficient - customers have documented savings of more than 60% based on the energy usage of a conventional system when replaced by a tote solution. It is also more cost-effective for high line capacities and are an attractive solution for systems with many loading/unloading positions, i.e. hubs. As with the cart system, the tote system can grow with the need for capacity increase at a reasonable low investment as the modular design allows for extension.

A key characteristic of a tote-based baggage handling system is its ability to handle higher capacity throughputs. It has been proven that a tote system is capable of running at 1,333 bags per hour through an ECAC (European Civil Aviation Conference) Standard 3 machine. By design, a tote system offers constant spacing of bags in the system.

By balancing the load from the check-in area equally to all machines available, the utilisation of the screening equipment is optimised. For larger systems, the screening machines are usually more distributed and spread between two or even more areas, which will then have to be linked by a reliable and flexible transport system. Here, a tote system can show its strength – higher speeds with a very reliable tracking of data and a flexible distribution for best utilisation.

- It allows for high redundancy concepts e.g. bi-directional cross-overs and reversing connection lines
- It allows for high-speed connections faster than conventional technologies
- It allows for secure transport and tracking in combination with in-tote screening
- Secure transport of difficult bags in special totes, including OOG and non-conveyable bags
- It has a low maintenance cost due to few spare parts and few moving parts
- It has low energy consumption with immediate stop function when bags are not present
- Allows for innovative storage solutions like rack-based storage with direct single bag access.

TECHNOLOGY COMPARISON

	Tote technology	Cart technology
Ideal application	For medium and high capacity sorting needing medium-speed transport with a limited number of discharges. System integrated in combination with conveyor system.	For high speed transport and lower capacity with a high sortation complexity. Many discharges on long distances. System integrated in combination with conveyor system.
Terminal layout	Suitable for airport layout with one or more terminals	Best for small and midsize terminals and systems as well as inter-terminal connection
Typical system application throughput	Typical system application throughput in the range of 2,000 to 20,000 bags/hour	Typical system application throughput in the range of 2,000 to 5,000 bags/hour
System size	Ideal system size: medium, large	Ideal system size: small, medium
Reliable operation, tracking, bag jams	Good for sorting. Very safe baggage handling. No tracking lost. No bag jams.	Good for sorting. Safest baggage handling. No tracking lost. No bag jams.
Hold baggage screening (HBS)	In-tote screening	On raw belt
Design capacity per line	3000 bags/hour	2500 bags/hour
Speed	Speed: 0.5 to 10 m/s	Speed: 0 to 10 m/s
Maintenance	Very low maintenance requirements. Simple equipment with very short replacement time (i.e. belt replacement = 2 minutes)	Lowest maintenance requirements. Track has no moving part (thus no maintenance). Carts can be repaired in a maintenance bay while system is in operation.
Relative CAPEX	Offers low/medium CAPEX	Offers low CAPEX (depending on flow/number of carts).
Relative OPEX	Very low OPEX (low power consumption, especially in systems that only run when the tote approaches). Low spare part and maintenance requirements.	Low OPEX. Few spare part requirements and very low level of maintenance.

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