

SWANSON  RINK

INDIVIDUAL CARRIER SYSTEMS

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TAKING RESPONSIBILITY

Individual Carrier System BHS

Study by Swanson Rink, Inc.

INTRODUCTION

There are a number of advanced baggage handling system technologies that have been implemented in Europe and other parts of the world, but are yet to be embraced in the United States. One of the more intriguing technologies is the Individual Carrier System or ICS. European airports that have successfully used ICS include Munich, Heathrow, Barcelona, Oslo and Helsinki. We have heard arguments that ICS is too expensive and the benefits don't justify the added cost; we decided to find out for ourselves.



Swanson Rink sought to determine if there is a business case for ICS in the United States. We started with a BHS project that is to be built in the US in the near future; a project of moderate size and complexity, with typical domestic loads similar to those at many major US airports. Our study made a comprehensive comparison of ICS technology and traditional conveyor technology, applied to a typical airport baggage handling system.

An ICS baggage handling system differs from a conventional conveyor system because it uses individual tubs or carts to convey baggage, instead of conveyor belts. Though there are hurdles for utilization in the United States, a strong argument can be made for ICS and we believe that it deserves a closer look.

We found that the ICS delivers improved baggage delivery both to and from aircraft. In addition to reduced travel time and reliable delivery energy usage, there are fewer tug train incursions on the apron, there is a smaller carbon footprint, and operating costs overall are reduced significantly.



In the ICS model, the travel time from aircraft to baggage claim, as well as check-in to makeup, is more direct and has the potential of minimizing ramp traffic. On inbound, tug trains travel a much shorter distance from aircraft to load pier which can be located near the aircraft rather than back at the terminal. Bags are loaded on containers and transported via ICS back to baggage claim, thus avoiding the drive back to the main terminal in the traditional approach. Tug traffic in the vicinity of active gates is minimized and the risk of fallen and damaged bags is reduced.

The advantages of ICS can be further increased if a common-use business model is employed for baggage handling. ICS requires fewer tugs and carts, thus the number of bag handlers can also be reduced. Costs can be substantially less where resources and related expenses can be shared.

Another benefit of ICS is the convenient application of Early Bag Storage. Since ICS uses RFID labeling on all tubs, vertical storage is practical, and Just-In-Time Delivery to outbound sort carousels can be accomplished. Makeup is easier and less risky since only bags for the particular flight need to be delivered to the makeup carousel or pier; there are fewer lost bags by virtue of limited manual intervention for sortation. Early bag storage can also improve efficiency of baggage screening operations when applied as a load leveling facility upstream of the baggage screening matrix.

APPROACH: TOTAL COST OF OWNERSHIP

We used a Total Cost of Ownership (TCO) analysis to compare traditional and ICS baggage handling technologies. The TCO analysis also allows for more visibility into the impact of the various cost centers considered, and the variances in each instance than can be discerned from a simple payback analysis. The individual cost center can be escalated according to historical trends for each, which lends further precision to the analysis. The TCO analysis identifies costs borne by each Stakeholder, and a comparison of the analyses identifies the costs and benefits that accrue to each Stakeholder.

Design criteria was developed using data from a recent design project, including flight schedules, electrical power costs, labor costs (including operating costs borne by TSA), BHS vendors and contractors, OEM contract rates and parts costs, and related environmental factors. All costs were validated with vendors and third party estimators for the purpose of this study.

A study period of fifteen years was identified, which is consistent with normal equipment and system lifecycles in the industry. The study period is long enough to capture real world normal operations, maintenance and replacement costs for major components.

The Return on Investment (ROI) analysis was used to augment the TCO analysis. The ROI analysis illustrates the relative “profitability” of ICS and each of its alternatives, and presents a simple payback period for each.

STAKEHOLDERS

Identification of major stakeholders was the first step in our evaluation of the baggage handling technologies. We identified three major stakeholders with vested interest in the successful construction and operation of a baggage handling system: the Airport, the tenant Airlines, and the TSA. Each stakeholder has unique operational responsibilities, bears particular costs, and realizes benefits from specific aspects of operation of the baggage handling system.

COST CENTERS

The next step of the analysis was identification of the major cost centers associated with ownership of a baggage handling system. Cost (and by extension, benefit) centers were assigned to stakeholders as they are traditionally found at most US airports.

The Airport was deemed responsible for procurement, construction and basic operation and maintenance of the BHS physical plant. Activities, such as belt and motor replacement, preventative maintenance and unplanned BHS repair, lie within the scope of services provided by the Airport. Utility costs to operate the BHS physical plant, and their associated environmental impact costs, are borne by the Airport.

Construction cost includes the construction contract value, contractors' general conditions, overhead and profit, and the BHS contractor's markup on their subcontractors. Also included are project "soft costs" borne by the Airport to facilitate execution of the construction contract.

Operations and Maintenance costs include spare and replacements parts, staffing costs for daily operation of the baggage handling system, as well as preventative maintenance and unscheduled repairs, and electrical utility cost required to power the system.

In our models, the Airlines are responsible for outbound and inbound bag room operations. The Airlines may operate autonomously, or may form a consortium which provides operational and maintenance services for the Airlines collectively. Activities such as staffing for the bag rooms, and ownership and maintenance of the baggage handling tug and cart fleet (which transports baggage to and from the aircraft) flow to the Airlines. Fuel and other utility costs associated with the operation of the tug fleet, and their associated environmental impact costs are also borne by the Airlines.



Baggage screening is the responsibility of the TSA. TSA provides the screening equipment which is a major portion of the baggage handling system, and they are responsible for staffing the screening matrix. TSA is responsible for staffing, operations and maintenance costs of the baggage screening equipment and the associated Checked Baggage Reconciliation Area (CBRA). EDS Matrix costs include initial installation, spare and replacements parts, staffing for daily operation as well as preventative maintenance and unscheduled repairs.

BAGGAGE HANDLING SYSTEM MODELS

Detailed system models were created for each system. The design concept was based on a peak flow rate of 2,750 bags per hour (BPH) outbound and 3,500 BPH inbound, with 12 load points including ticket counter positions, curbside drops and remote check-in, and 18 inbound load piers. (This is an arrangement common to many midsize airports and large airports with multiple

terminals). Surges, jams and component failures were also addressed. Performance models assume a maximum of 23 concurrent outbound flights and 16 concurrent inbound flights.

There are two major operational differences between ICS baggage handling technology and traditional conveyor technology. The first difference is that the ICS system is a loop rather than a one-way delivery system. Tubs are circulated around the loop and returned to the baggage load points as necessary for baggage transport. The loop design offers a natural path for inbound baggage transport to claim devices, eliminating the need for a substantial amount of tug traffic on the apron.

The second difference is that ICS uses containers to separate and transport bags. ICS containers (tubs or totes) are consistent in size, and are larger than ordinary baggage. Larger tub size (48" versus 30" for the bag alone) reduces the processing capacity of the EDS scanner by approximately 25% compared to a traditional BHS. This reduction in capacity can be partially offset by the improved processing accuracy of the ICS system.

The model for the traditional BHS was developed following normal industry-accepted design practices. BHS subsystems include airline-dedicated baggage loading points, baggage transportation to common mainline conveyors, integrated inline baggage screening, checked baggage reconciliation, outbound sortation delivering baggage to airline-dedicated sort carousels, and airline-dedicated inbound baggage handling and baggage claim.



Passenger ticketing and outbound baggage loading is accomplished on the departures level at dedicated airline ticket counter positions. Unscreened baggage is collected onto two delivery mainline conveyors and transported to the checked baggage inspection system (CBIS) screening matrix located on the ramp level at the junction of the terminal and concourse. The CBIS contains five active (plus one standby) EDS scanners and their complement of Level 3 baggage screening stations. Screened baggage is transported,

via two mainline conveyors, past two manual encode stations to outbound bag rooms located at the ramp level.

Inbound baggage is collected from arriving aircraft and transported via airline dedicated tugs and carts to specific inbound load piers located on the ramp level. Inbound delivery conveyors transport baggage to their respective claim units located on the arrivals level.

The model for the ICS-based BHS was developed following manufacturer's recommendations and industry best practices as they apply to an ICS design. As with the traditional conveyor belt system, passenger ticketing and outbound baggage loading is accomplished on the departures level of the Terminal. For ICS however, unscreened baggage is loaded directly into Individual Containers (tubs) at the ticket counter load points, collected onto delivery mainline conveyors and

transported to a pre-CBIS bag storage/screening load leveling facility. The number of scanners and screening stations is the same, in part due to the pre-CBIS bag storage.

We also looked at several variations on the ICS theme in order to gain a better understanding of the true potential of the technology. The greatest benefit accrues when post-screening baggage storage, common use outbound sortation, and common use inbound loading are incorporated into the ICS design. Though these functional capabilities can be provided with current traditional conveyor belt technology, the cost with the conventional approach does not result in comparable benefits.

CONSTRUCTION COST

Rough Order of Magnitude (ROM) construction cost estimates were prepared for the traditional conveyor and ICS options. The baggage handling contractor was assumed to be a first tier or prime contractor, and construction costs were calculated in current (2014) US dollars. ROM estimates include a detailed material and labor take off for the major system components and general conditions and other overhead expenses, contingencies and escalation. Differential costs for general building construction required by one option over the other are included as well.



OPERATIONS AND MAINTENANCE COST

Operational costs for the baggage handling systems considered number of staff per shift, spare and replacement parts, OEM maintenance contract costs, and electrical power consumption by the respective systems. Costs associated with operation of the inbound and outbound bag rooms are similar and include the costs for tug power consumption, maintenance, and staffing to load transport and unload baggage. TSA operational costs include screening matrix staffing and OEM maintenance contracts. Operations and Maintenance costs on an annual basis are tabulated below.

| Cost Center | Traditional BHS | ICS |
|--------------------------------|------------------------|--------------|
| BHS Maintenance (spare parts) | \$947,000 | \$1,295,000 |
| BHS Maintenance Staffing | \$3,733,000 | \$3,344,000 |
| BHS Utilities (electric power) | \$132,000 | \$176,000 |
| Tug Maintenance (parts, labor) | \$776,000 | \$400,000 |
| Bagroom Staffing | \$14,648,000 | \$10,571,000 |
| Tug Power | \$158,000 | \$54,000 |
| EDS Maintenance | \$420,000 | \$420,000 |
| TSA Staffing | \$13,800,000 | \$10,200,000 |
| EDS Utilities (electric power) | \$13,000 | \$13,000 |

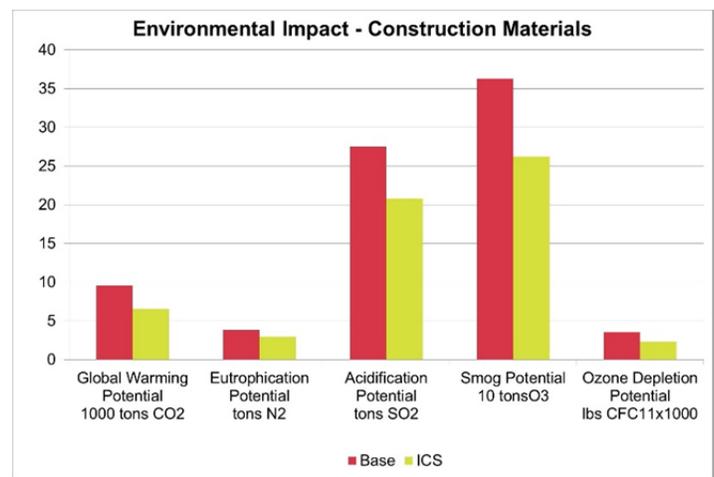
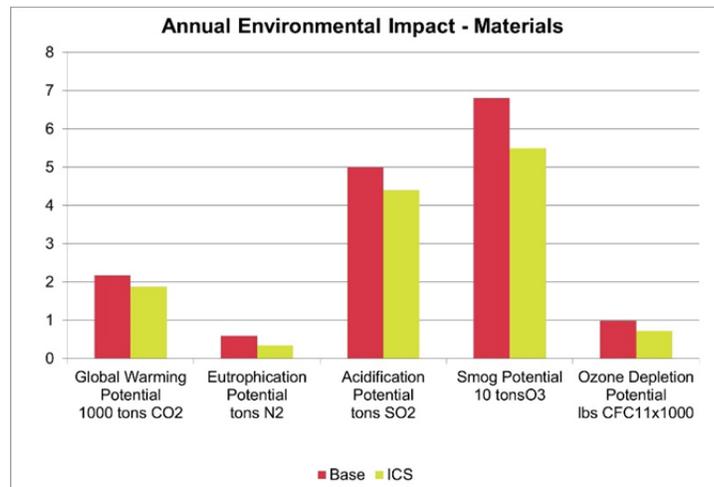
SUSTAINABILITY

The environmental impact of construction and operation of each baggage handling technology was assessed and five environmental impact categories were looked at:

- 1) Global Warming Potential (Climate Change) in terms of greenhouse gas emissions.
- 2) Eutrophication or potential impacts of excessively high levels of macronutrients.
- 3) Acidification or reduction in pH and ecosystems mortality.
- 4) Smog potential.
- 5) Ozone depletion.

The evaluation was done in the context of current *LEED Version 4* criteria for building construction and took into account operations and use of consumable and reusable materials. Construction materials evaluated included conveyor belting, steel, copper (motor windings), lubricating oil, paint, tug battery packs (all carts are assumed to be electric) and tubs (HDPE). Environmental impact was analyzed for both construction and annual operations.

Factors contributing to Environmental degradation were found to be substantially reduced by the use of ICS technology. Impact on the climate, energy, and other environmental impacts are all reduced for the ICS option as shown in the charts and table.

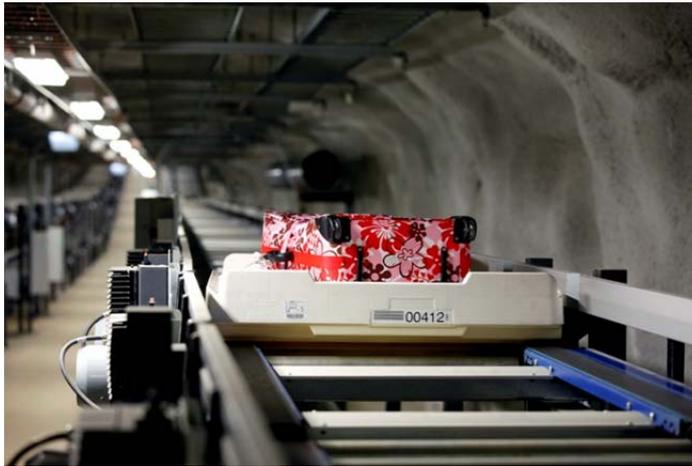


| Environmental Factors | Traditional | ICS | Reduction |
|--|-------------|--------|-----------|
| Global Warming Potential - tons CO2 | 9560 | 6570 | 31% |
| Primary Energy - MWhrs | 29,800 | 20,200 | 32% |
| Eutrophication Potential - tons N | 3.81 | 2.99 | 22% |
| Acidification Potential – tons SO2 | 27.5 | 20.8 | 24% |
| Smog Potential – tons O3 | 363 | 262 | 28% |
| Ozone Depletion Potential – lb. CFC-11 | 3.59 | 2.35 | 35% |

The sustainability information provided above was developed by thinkstep (www.thinkstep.com).

PASSENGER EXPERIENCE

Ticketing and Baggage Claim have been identified as areas where innovative baggage handling system design and operation could improve the passenger experience. Innovations such as self-check-in and bag tagging can be applied to either BHS technology. ICS technology offers the opportunity for performance improvement in delivery of inbound bags to the claim devices.



Passengers expect their bags to be present when they reach the claim unit at their destination, and ICS is very effective on inbound baggage delivery. We performed dynamic simulations on traditional and ICS designs, which considered the time to unload the aircraft to carts, drive to the stripping belts and unload the carts to the carousels. This also includes the time for inbound tugs and carts to drive to a stripping belt at the terminal for the traditional conveyor system. For the traditional design, the first bag arrives

at the claim device 22 minutes after flight arrival, 50% of bags are delivered within 40 minutes, and 95% are delivered within 77 minutes. For the ICS design, the first bag arrives 20 minutes after flight arrival, 50% of bags are delivered within 36 minutes and 95% of bags within 50 minutes. ICS offers savings in time but also efficient use of resources. The risk of incursions and injury is also reduced significantly.

The ICS design offers the additional benefit that the travel time from aircraft to claim units is more repeatable. In the ICS option, the tug trains travel from aircraft to load pier(s) located along the concourse, avoiding the majority (if not all) of the aircraft parked at or approaching/departing the gates. For a traditional design, tug traffic travels on the ramp from the aircraft to the inbound load piers located in the terminal. Tug traffic in the vicinity of active gates must stop and wait for arriving or departing aircraft to pull in or push back from the gate before proceeding to the terminal. These delays are random and add approximately 5 minutes to the baggage delivery time.

ACCOUNTABILITY AND TRANSPARENCY

A common problem with traditional baggage handling systems is mishandling of bags within the system, sometimes referred to in the industry as 'bags lost in tracking'. Bags are tracked using photoeyes and belt speed to determine bag location. When bags slip or tumble on conveyors, the known location is lost. There are many causes of slippage, but one is poor bag hygiene, i.e. bags placed on belts with wheels down, askew on the belt, or adjacent to other bags.

Barcode tags may be tracked, but that technology is expensive and most reliable when their laser heads are clean. Common performance of bar code reader arrays is 85% accuracy, unless the laser heads are kept meticulously clean. Handheld barcode readers have better performance, but often require excessive lengths of time to achieve a successful tag read.

ICS containers are fitted with a permanent RFID tag which uniquely identifies the tub, and tracks the bags through the system. The result is the tracking accuracy rises to 99% with ICS, and possibly higher depending on the complexity of the system. To assure this level of accuracy however, the bag must remain in the tub for as long as possible from bag drop at check-in to the aircraft. The BHS control system can accurately report bag location at many more locations within the BHS, making the system operator accountable and making it possible to inform passengers where their bags are, and when they made it onto the aircraft.

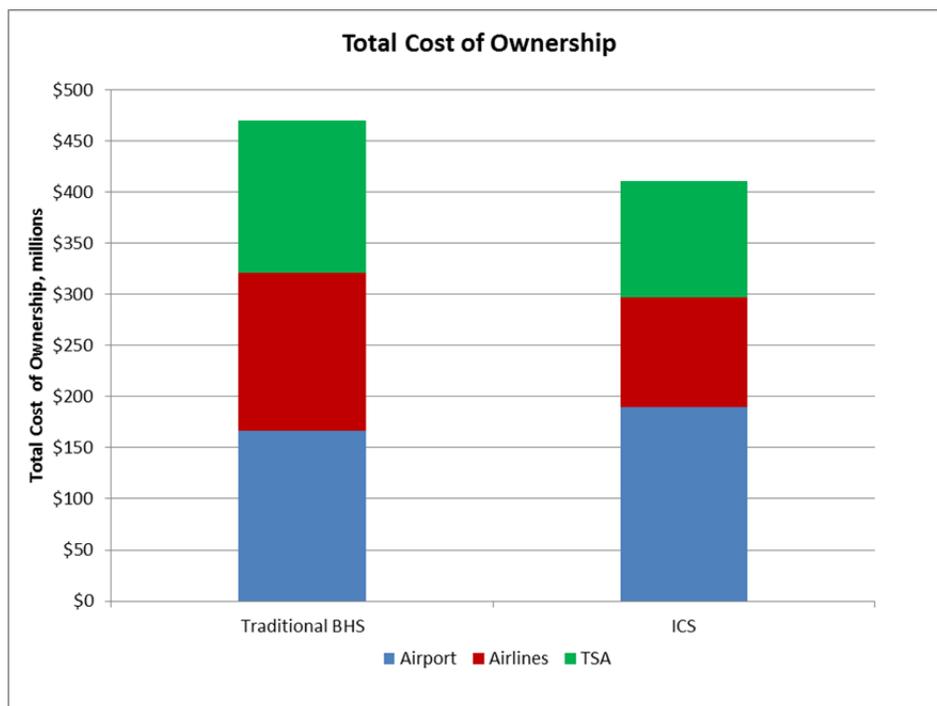
Bags can more efficiently be delivered to the outbound sort carousels, and can be delivered to inbound claim devices with a lower risk of ramp incursions. Reduced tug train drive times and fewer lost or damaged bags can be realized when the bags are delivered as close as possible to the aircraft.

TOTAL COST OF OWNERSHIP

Cost centers considered in the Life Cycle Cost Analysis include Capital cost, and annual Operating and Maintenance cost as described above. Costs were also broken down by stakeholder and reflect the present value Total Cost of Ownership.

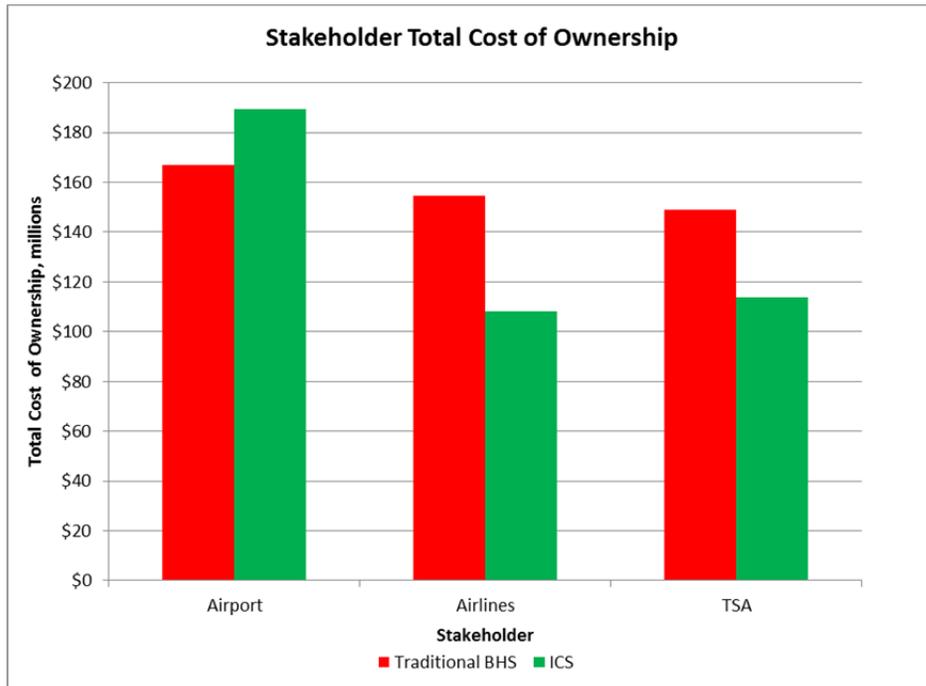
Initial construction cost for ICS based baggage handling system is higher than for a traditional design, but the total cost of ownership is significantly lower.

| | Traditional BHS | ICS |
|-------------------------|-----------------|---------------|
| Total Cost of Ownership | \$470,497,000 | \$411,110,000 |
| Construction Cost | \$120,738,000 | \$143,121,000 |



The initial added cost for construction of an ICS system is \$22,383,000 with a total savings over 15 years of \$59,387,000 in today's dollars, and an annual ROI of 6.75% over the 15 year period. Recovery of the initial added cost is realized in just a little over three years.

Costs were also broken down by stakeholder, which is displayed in the chart below.



Though the long-term gain for the Airport (who bears most of the capital cost) is smaller, all primary stakeholders look to gain by deployment of an ICS based baggage handling system.

CONCLUSION

This study shows that the ICS technology has obvious benefits including more reliable delivery of bags, less bag loss, reduced ramp incursions and overall reduced cost of ownership.

Most of the advantages of ICS can be best realized only if there are changes in the way bagrooms are managed. Traditionally, BHS operations are handled by each airline separately.

ICS works best in a common use environment where resource costs can be shared for baggage handling, check-in and operations and maintenance of the system.

Special thanks goes to Vanderlande Industries and Beumer Group, two of the leading providers of ICS in Europe who were very helpful in providing technical support for our study.