

SINGAPORE CHANGI AIRPORT



Baggage handling system makes fast connections

Singapore Changi Airport - and Crisplant - certainly had reason to celebrate that New Year. January 2008 marked the successful operation of a major baggage handling and high-speed transfer system at the new Terminal 3 - delivered on time, and still on the fast track.

Case Study Singapore Changi Airport

SUPPORTING AN AWARD-WINNING REPUTATION

With a capacity of 22 million passengers per year, Terminal 3 offers a swift, pleasant and modern airport experience reinforcing Changi's award-winning reputation for exceptional service. Besides the unique architecture and the unparalleled service, Crisplant's ultra-efficient, highly reliable baggage handling system is one reason why.

Changi Airport has been showered with awards. Today the airport ranks among the world's best, and the millions of passengers who travel through Changi each year have learned to expect fast, efficient service that sends them on their way with friendly service and a genuine smile.

A major aviation hub in Southeast Asia, Changi is recognised as one of the most advanced and passenger-friendly airports in the world. The ultra-modern facility has 19 Airbus A380-compatible gates, including eight in the new Terminal 3. In fact, the world's first A380 commercial flight operated by Singapore Airlines made its debut in Changi Airport.

With such an impressive pedigree, expectations for Changi's baggage handling system were high. Maximum operating performance, security, efficiency and reliability were musts for the chosen supplier.

Leading the project

The Civil Aviation Authority of Singapore (managing Changi Airport at that time) awarded the contract to Crisplant, who

designed and engineered the new inter-terminal baggage transfer system, including a state-of-the-art computer control system. Crisplant was also appointed leader of a consortium to build and the fully automated the baggage sorting system for Terminal 3.

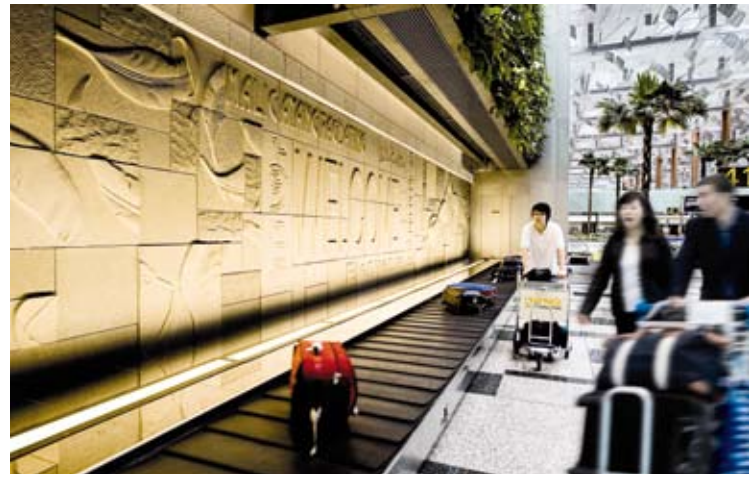
In addition, Crisplant was awarded sole responsibility for the operation and maintenance of the baggage handling systems in both Terminals 2 and 3 and the inter-terminal baggage transfer system, following installation. Crisplant personnel operate the baggage control room 24/7, providing operational management and preventive maintenance to ensure optimum system availability and performance.

Emulation shortens lead time, ensures room to grow

Terminal 3 is designed to accommodate the requirements of a growing hub operation. By conducting numerous tests using specialised simulation and emulation software technology, Crisplant has been able to ensure that the baggage handling system will cope confidently with passenger growth forecasts through Terminal 3's design capacity and possibly beyond.

The extensive use of emulation also helped Crisplant deliver the extensive project both on schedule and much faster than the normal lead-time required for projects of such scale and complexity. Emulation can push the speed of the system to a level far beyond the demand for performance, forcing everything to run faster than real time and thereby submitting the system to a stress





level higher than the actual mechanical system.

The emulation process ensures that the high-level and low-level software is fully tested before shipment to the airport.

Baggage handling system scope

Among Changi Airport's specifications for Terminal 3, the highest priorities were fast, safe, reliable and flexible transport of baggage. Short processing time was required to handle each bag from check-in to selected make-up position.

To meet Changi's requirements, the system for Terminal 3 is based on two tilt-tray sorters, each some 1,000 m (3,281 ft) long, a 13,000 m (42,651 ft) CrisBag™ system for the high-speed connection between terminals and for early baggage storage, check-in conveyors, racetracks, claim carousels and a SCADA control system.

First CrisBag™ installation in Asia

Changi Airport uses the CrisBag™ system as an extensive inter-terminal transfer baggage system to connect Terminals 1, 2 and 3 as well as for sorting baggage in Terminal 3. In addition, the system stores up to 4,000 pieces of luggage at a time in a fully integrated early bag storage (EBS) system. The EBS system has been built in four storeys, and the full CrisBag™ transport system measures 13 km (8+ miles).

The CrisBag™ totes enable 100% track and trace at all times. When loaded on



the system, each item is placed in a numbered tote and the bag's IATA barcode data is merged with the tote's RFID information. The tote number, which is readable at all times, enables precise monitoring of individual pieces of luggage while in the system. A special design allows gentle transportation of all baggage types, shapes and sizes, including out of gauge (OOG), at speeds of up to 7 m/sec (23 ft/sec), boosting Changi Airport's competitive advantage.

Simulation and emulation technology enables Crisplant to ensure that the baggage handling system will cope reliably with passenger growth forecasts.

CrisBag™ gently transports all baggage types, shapes and sizes at speeds of up to 7 m/sec (23 ft/sec).

BAGGAGE HANDLING WORKFLOW

Check-in

During baggage check-in, the baggage handling system (BHS) interfaces with airlines' departure control systems to obtain the baggage source messages (BSM). The BHS processes the BSMs, which are used to identify, route and track the bags all the way to their intended destination. The baggage handling system allows 100% hold baggage screening.

Tilt-tray sorters in main bag room (MBR)

The two tilt-tray sorters in the MBR are Crisplant's quiet, highly reliable sorters with a low-maintenance electronic tilt mechanism. The induction conveyors feed bags from the conveyor lines into the two tilt-tray sorters. Each tilt-tray sorter is equipped with automatic bar

code laser scanners as well as RFID tags on each cart to enable faster synchronisation during start-up or fail over to redundant controls.

Bags are tracked on the conveyors in the MBR and sent to the sort conveyor. Based on the bag identity, the baggage handling system determines whether baggage should be directly sorted via the sorters, should go to early baggage storage or should be transferred between terminals.

Automatic barcode scanners on the tilt-tray sorters enhance the tracking information for even higher levels of sorting accuracy. Bags can be sent to the manual encoding stations if tracking information is lost, while rush and odd-size bags are sent to their respective outputs.



An automatic barcode scanner on each line automatically scans the bag tags for accurate transfer.



Finally, based on scanned barcode data and the system's programmed instructions, bags are routed to the appropriate chute among the 102 make-up chutes at a speed of 1.9 m (6+ ft) per second.

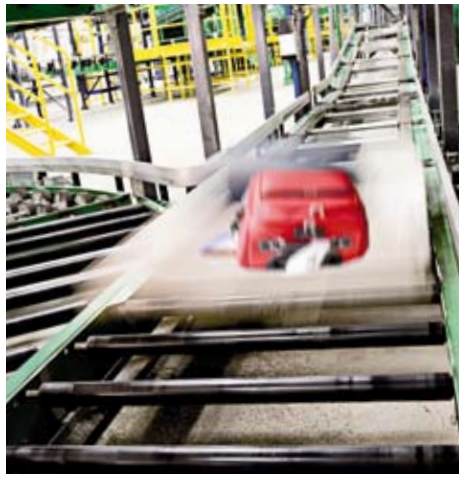
Transfer input facility (TIF)

Transfer baggage accounts for approximately 53% of the total amount of baggage processed in Terminal 3.

At the TIF, five dedicated transfer input lines with barcode scan and HBS screening route bags into the CrisBag™ system for EBS, sortation to make-up or time-critical racetrack.

Tunnel transfer

Transfer operations always become more complicated with three terminals, and transfer speed is clearly of the essence. With a point-to-point transport speed of 7 m (23 ft) per second, the CrisBag™ is



With a speed of 7 m (23 ft) per second, CrisBag™ is ideal for high-speed baggage transportation between terminals.

ideal for high-speed baggage transportation. The 1,200 m (3,937 ft) underground tunnel connecting Terminals 1, 2 and 3 features a two-storey track in each direction and is optimised for the highest possible throughput. The conveyance time for baggage of transfer passengers making connections at different terminals is required to be as short as possible without compromising reliability.

Importantly, it is also possible to reverse the transport direction for maintenance purposes or fault recovery while maintaining full tracking.

Early baggage storage (EBS) with automatic retrieval

Crisplant integrated an EBS solution for intermediate storage of baggage arriving before the make-up chute is scheduled to be assigned. Unlike most systems, the fully automated CrisBag™ EBS system makes it possible to pick out single totes at any time.

A fully integrated storage facility, the CrisBag™ EBS allows passenger bags to be checked in hours before flight time as well as storage of transfer bags with long connecting time. Bags are stored in a high-density matrix and then routed to the corresponding flight during the correct make-up window. Baggage remains in the same dedicated totes during storage. The 100% accurate track-and-trace system ensures that each bag's exact location is always known, and any item can be quickly called out from the storage system at any time, such as in the case of re-booking.



Early bags can enter the integrated EBS from the main bag room, and the TIF and an inventory management system (IMS) automatically keep track of up to 4,000 baggage items stored in the EBS at one time.

Empty tote stackers at each loading station not only make very space-efficient storage but also ensure that each loader has a sufficient number of totes at all times.

Baggage remains in the same dedicated totes during storage in the CrisBag™ EBS system for 100% accurate track and trace.

Software and control system

The airport's challenging software demands have been met by using an advanced high-level control system. Built from field-tested and proven modules of the Crisplant Software Suite™, the system is based on a hierarchical and highly modularised control philosophy and can easily be expanded to meet future needs.

The control system, a vital component, ensures flexible and reliable performance in the new terminal. The sort allocation computer (SAC) allocates baggage destinations and automatically performs continuous updates based on the current flight schedule via an interface to the



flight information system (FIS). The SAC also handles CrisBag™ early bag storage, including optimum use of the storage. The control system is built for more than 99.99% availability.

The SCADA, known as MDS (maintenance and diagnostic system) in Changi Airport, enables the operator to visualise and supervise the entire baggage handling system and to handle error situations quickly and effectively.

The CrisBag™ control system also comprises a CrisBag™ system controller (CSC) that takes care of flow control, flow routing and overall monitoring of the CrisBag™ system, including handling flow of empty totes back to loading stations.

In addition, 44 redundant machine controllers (PLCs) are used to provide real-time control of the elements in the CrisBag™ system. Each of the 6,000 frequency-controlled motors, 20,000 sensors and other peripheral devices are

connected to the machine controllers via profibus for full control of the system.

This ensures full track and trace of the 4,000 totes that transport every passengers' bag. To ensure easy replacement and smooth operation, all individual settings for the frequency inverters are controlled and downloaded from the CrisBag™ CSC.

Energy-conscious baggage handling

CrisBag™ offers the potential for significant energy savings. Rather than running continuously, the belts only start when prompted by the arrival of baggage, stopping again once the bag has moved on to the next module. The fact

that bags are loaded onto light totes weighing no more than 20 kg also ensures lower system energy consumption.

By ensuring uniform speed at both sections where a tote travels from one section to the next, the control system prevents unnecessary tote wear and tear and extends tote lifetime. Longer lifetime of working components has also been achieved by dividing the transport lines into modules, each with a motor.

Service fit for a winner

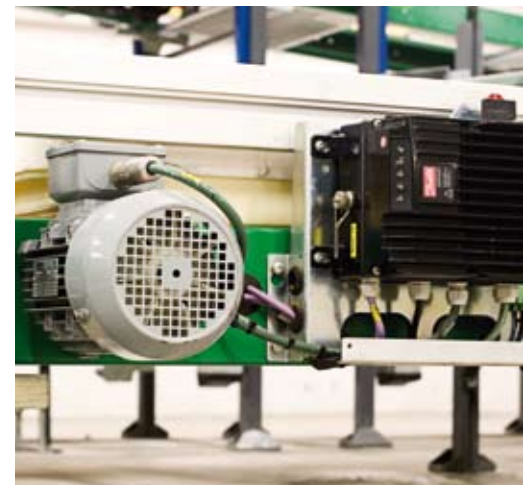
To ensure maximum operational security for the airport's baggage handling system, Changi Airport Group (Singapore), who has taken over from the Civil Aviation Authority of Singapore as the licensee to operate Changi Airport, entered a full operations and maintenance service contract with Crisplant personnel stationed round-the-clock on site where the control system monitors and controls the entire system and server rooms.

Crisplant is solely responsible for ensuring optimal operation and maintenance of the baggage handling systems. Preventive maintenance is carried out as required and the latest technological upgrades made available as they arrive.

A 121-person team manages the job in three shifts, seven days a week. Should a situation arise where more personnel are required, additional Crisplant technicians are ready on short notice. Their role is to secure optimum system availability and to ensure the baggage handling system's long-term capabilities. With the full service contract, airport staff can concentrate on their primary tasks, knowing that the service and maintenance of the highly specialised baggage handling



system is under control. With the mission critical baggage handling system soundly in Crisplant's hands, Changi Airport can continue to meet the expectations of the passengers whose feedback contributed to the airport's tradition of excellence.



CrisBag™ saves energy by starting and stopping belts according to need.

CHANGI AIRPORT

Baggage handling system summary

Terminal 2

Two tilt-tray sorting machines, automatic inductions and automatic reading stations (for 10-digit IATA barcode labels). 16 inductions, belt conveyors and early baggage storage for 2,200 bags. 100% automatic HBS system with integration of both high-level and low-level control into the BHS control system.

S-2000M Tilt-Tray sorters

Sorter 1: 450 m (1,476 ft)
Sorter 2: 600 m (1,969 ft)
Capacity: 10,800 bags/hour

Terminal 3

Check-in conveyors, automatic inductions, racetracks, claim carousels, hold baggage screening, two tilt-tray sorting machines with a total of 102 make-up chutes and 14 make-up carousels. 13 manual encoding positions to re-encode bags, 76 redundant machine controllers (PLCs), 32 machine controllers. SCADA control systems. A CrisBag™ tote system is used for early baggage storage for 4,000 bags and transfer between terminals. 100% automatic HBS system with integration of both high-level and low-level control into the BHS control system.

S-3000E Tilt-Tray sorters

Sorter 1: 980 m (3,215 ft) Sorter 2: 1,020 m (3,347 ft)
Capacity: 10,400 bags/hour

CrisBag™ system based on:

Baggage handling elements
Transport elements
Flow split/merge elements
Storage elements
CrisBag™ standard and oversize totes

Transport speed: Up to 7 m/sec (23 ft/sec)
CrisBag™ length: 13 km (8+ miles)
Capacity EBS: 4,000 totes
Capacity: 2,700 totes/hour per line (high-speed transfer lines between Terminals 1, 2 and 3)

Full-service operation and maintenance contract in Terminals 2 and 3

- 24/7/365 support and operational reliability
- Spare parts
- Full programme of preventive maintenance
- System analysis and optimisation
- New technology upgrades
- Consultancy services
- Supplementary stand-alone products



ABOUT CHANGI AIRPORT

- 73+ million passenger capacity a year (including budget terminal)
- 86+ airlines operating more than 4,880 weekly scheduled flights
- Connects Singapore to 201 cities in 60+ countries

Departure handling capacity

Terminal 1: 7,200 bags/hr
Terminal 2: 10,800 bags/hr (plus 3,600 transfer bags/hr)
Terminal 3: 10,800 bags/hr (plus 5,400 transfer bags/hr)

Arrival handling capacity

Terminal 1: 5,000 bags/hr
Terminal 2: 5,000 bags/hr
Terminal 3: 5,000 bags/hr



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