ANNEX

Factsheet on the First Aviation Challenge

The Aviation Challenge was launched in 2014 with the objective of developing innovative solutions to automate labour-intensive processes in airport operations.

The first Aviation Challenge sought to reduce the physical strain of baggage handling on workers, caused by labour-intensive tasks such as the manual loading of bags into trolleys and stacking of bags inside an aircraft cargo hold, by automating the baggage handling process for narrow-body aircraft.

The Civil Aviation Authority of Singapore (CAAS) worked with five teams in the first Aviation Challenge to develop prototypes that could potentially automate the entire baggage handling process for narrow-body aircraft from departures to arrivals / transfers. Teams were awarded a total of S$9.2 million in funding to develop prototypes. The teams were:

1. Ctrlworks Pte Ltd
2. Cyclect Electrical Engineering Pte Ltd
3. Singapore Aerospace & Aviation Services Pte Ltd
4. Singapore Technologies Dynamics Pte Ltd
5. Temasek Polytechnic

The teams started prototype development in September 2015 and completed development in July 2017. The prototypes were then assessed by an evaluation panel comprising key members of the airport community – CAAS, Changi Airport Group (S) Pte Ltd, SATS Ltd, dnata Singapore Pte Ltd, Singapore Airlines Ltd, and SilkAir (Singapore) Pte Ltd.

The different stages of the baggage handling process that the teams endeavoured to tackle were as follows:

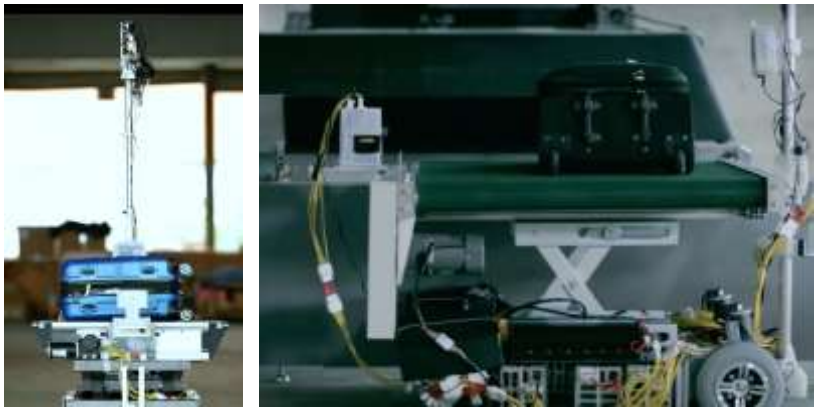
Baggage Handling Process: ***Departure*** *Stage*		
		
Reconcile & Build	*Transport of Bags*	*Loading into Cargo Hold*
After check-in, bags are sent to carousels using a baggage handling system. The bags are then reconciled to ensure they are loaded to the correct flight, and manually loaded into trolleys.	The trolleys are manually towed by tractor to the departing aircraft. Up to four trolleys are towed at any one time.	Bags are then manually unloaded from the trolleys onto a conveyor belt loader. Apron assistants also need to sort bags inside the aircraft cargo hold, as it can be as deep as 10 metres long.

Baggage Handling Process: ***Arrival / Transfer*** *Stage*		
		
Unloading from Cargo Hold	*Transport of Bags*	*Offloading onto Arrival Belt*
After an aircraft stops at the gate, apron assistants will unload bags from inside the cargo hold onto a conveyor belt loader. Other apron assistants will pick up the bags off the belt loader, and place them inside the trolleys.	The trolleys will then be manually towed either to their respective transfer belts (where they will be sent to the next departing flight) or arrival belts (where they will be offloaded).	Bags for arrival reclaim will then be offloaded manually from the trolleys.

More information on the prototypes developed by the five participating teams is as follows:

Ctrlworks Pte Ltd

The Ctrlworks concept uses scalable and flexible conveyor Mover automated guided vehicles (AGVs) that can be deployed in a range of flexible scenarios. This reduces the need for fixed infrastructure and rigid work processes. It also allows flexible deployment of manpower and lead to higher productivity. The prototype stands out because it is deployable, practical and economical.



Mover AGV

The Mover AGV will then transport the bag and unload it onto the trolley, saving manpower and effort. When multiple mover AGVs are used, the solution will be able to meet the baggage handling throughput required for the airport.

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Cyclect Electrical Engineering Pte Ltd (Cyclect)

The highlights of Cyclect's solution, called CLAIRS (Cybernetics, Logistics, Automated, Intelligent, Robotic System), are:

- The CLAIRS Robotic Handler, with a specially designed gripper that can allow it to pick bags directly off the carousel and load into a trolley;

CLAIRS Robotic Handler

- The CLAIRS Smart Trolley, with a built-in vision dimensioning system, space optimisation algorithm and RFID readers working together that automatically orientate, allocate a bag into designated compartment and log its respective location for performing baggage reconciliation and retrieval; and

- The Cyclect Smart Suit, which is a lightweight exoskeleton that can be worn by workers to protect their backs from injuries when handling bags in the cargo hold.

CLAIRS Smart Trolley

Cyclect Smart Suit

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Singapore Aerospace & Aviation Services Pte Ltd (SAAS)

SAAS' solution is made up of two parts: the UniArm and the UniLoader.

UniArm

UniLoader

The UniArm is a controllable sliding platform that interfaces between baggage trolley and carousel. This enables a more ergonomic and faster way of transferring bags between the trolley and the carousel. Passenger bags are better handled with less damage. Also the solution delivers a potential manpower saving of up to 50%.

The UniLoader is a combined tractor-trolley equipped with powered conveyors. The design concept serves three functions: tow a train of baggage trollies for a flight; carriage of up to 60 bags; and serve as a 'vehicle-architecture' for airport application of automated guided vehicles (AGVs).

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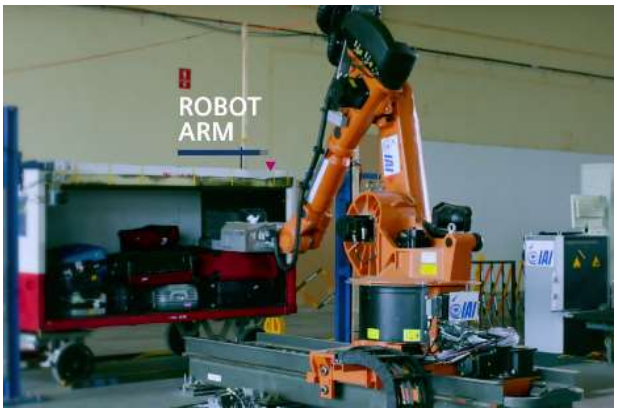
Singapore Technologies Dynamics Pte Ltd (ST Dynamics)

(The Advanced Engineering Center of ST Engineering)

ST Engineering, together with Israel Aerospace Industries Ltd (IAI), developed an autonomous solution for baggage handling operations. The solution aims to address the shortage of ground handling staff, and ease the physical exertion in performing their duties.

In summary, the solution automates the baggage tracking, sorting and loading process through the use of bar-code readers, fully automated baggage sorting and transfer systems, robotic arms, and a multi-flight baggage handling software suite. It also uses unmanned autonomous baggage tractors (ABTs) to transport the baggage trolleys between the aircraft and baggage handling areas, and a Baggage Trolley Offloading system to automatically transfer baggage of incoming flights onto the airport arrival carousels.

Baggage Transfer System



Robotic Arm

Autonomous Baggage Tractor

Baggage Trolley Offloader

For departures, a baggage scanning system scans and detects baggage specific information using barcodes, and directs each bag to its respective flight's trolley.

A baggage transfer system, installed on top of the baggage carousel, then directs each bag to the appropriate robotic arm for loading onto the correct baggage trolley corresponding to its flight. The robotic arm, equipped with a special telescopic end-effector, will then load the bags automatically into the trolley.

For the transport of bags, the autonomous baggage tractor (ABT) is a retrofit of an existing baggage tractor vehicle with an autonomous add-on kit, and is able to navigate autonomously with RFID transponders and Global Positioning System (GPS).

For arrivals, an automatic Baggage Trolley Offloader is used for the arrival baggage handling process. The Offloader lifts the fully loaded baggage trolley, tilts it and automatically transfers the bags onto the baggage conveyor belt quickly, and without the need for manual offloading of each bag.

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Temasek Polytechnic (TP)

TP's prototype consists of three components – the Automated Baggage Trolley (ABT[1]), Lifter and Feeder Conveyor – that, together, seek to automate the baggage handling process from the baggage carousel to the aircraft.

The ABT is a compartmentalised trolley that is powered to load and unload bags with its own roller conveyor system. The Lifter transfers bags between the baggage carousel and ABT and reduces the strain and workload of the operator. The Feeder Conveyor transfers bags between the conveyor belt loader at an aircraft and ABT automatically. Operators are no longer required to lift and carry heavy bags during the transfer.

Automated Baggage Trolley and Lifter

Feeder

The prototype has twin objectives of reducing manpower through automation and reducing the physical strain on operators. This is a robust and cost-effective system that is simple to deploy and operate. The prototype is designed to operate within the confines of the existing baggage handling area and interface with existing ground handling equipment. The ABTs and Feeder Conveyor are powered by their own rechargeable batteries and hence do not need to tap external power sources at the ramp. If required, the ABTs can move under their own power, without the aid of tow tractors.

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[1] Not to be confused with the Autonomous Baggage Tractor by ST Dynamics Pte Ltd.