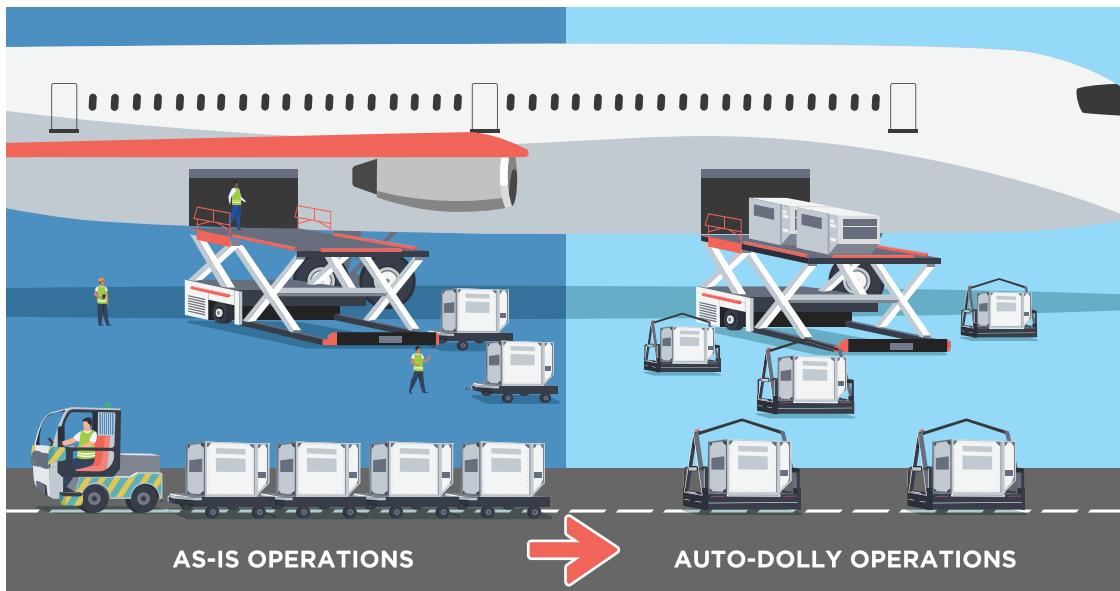


## A REDESIGN OF THE “1 TRACTOR + 4 TRAILERS” CONCEPT



Current operations involve a manually-driven baggage tractor towing up to four carts or trailers

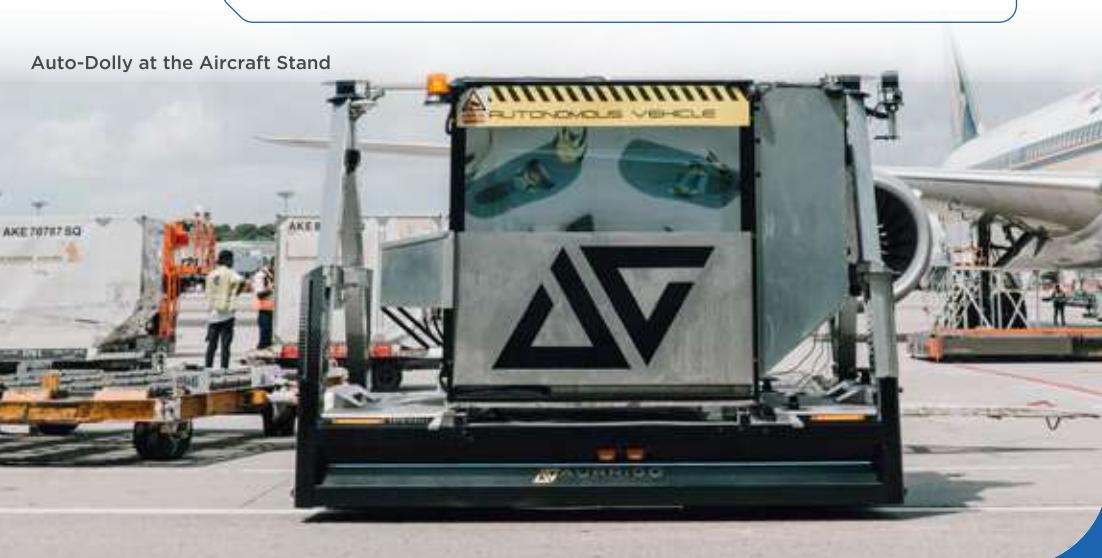
→ Individual Auto-Dollies each act as an independent cart or trailer transporting baggage to/from the aircraft stand

### FUTURE PLANS

- Subsequent trial phases will see newer iterations of the Auto-Dolly vehicle, incorporating several design changes
- Future versions of the vehicle will have the “crabbing” ability - besides moving forward and backward, it will be able to turn on its axis to move sideways in order to increase its manoeuvrability, allowing it to operate efficiently within an aircraft stand



From May 2021 - May 2022, the Civil Aviation Authority of Singapore, Changi Airport Group and Aurigo embarked on a joint Autonomous Baggage Automation for Changi Airport Stakeholders (ABACAS) project to trial the Auto-Dolly at Changi Airport, funded by the United Kingdom's innovation agency under the Eureka programme.



# LIKE CLOCKWORK: THE WORLD BELOW THE WING

At all airports, the movement of baggage and cargo form a significant portion of activity at the airside.

## 1 Aircraft Stand

Upon arrival, baggage and cargo are unloaded from aircraft onto carts or trailers and are towed by tractors to the Baggage Handling Area under the Terminal Buildings, and the Air Freight Terminals respectively.

The reverse process takes place for departures.



**DID YOU KNOW?**  
There are close to  
**2,000**  
specialised drivers supporting aircraft ground handing at Changi Airport



## 2 Baggage Handling Area

Arrival baggage is unloaded from the carts or trailers directly onto the baggage carousels which connect to the baggage claim belts in the terminals.

For departures, checked baggage travels through a series of conveyor belts and is routed to the baggage carousels, upon which airport staff will proceed to scan the baggage barcodes and sort the baggage into carts or trailers, to be sent to the respective flights.



## 3 Air Freight Terminals



Photo courtesy of Singapore Airport Terminal Service (SATS)



## The Future of Airside Baggage & Cargo Transport: Autonomous Vehicles

- Airside drivers spend a significant amount of time plying the airside roads getting from point to point
- Autonomous Vehicles could transform the delivery of baggage and cargo and enable drivers to perform other more urgent and complex tasks, especially within the aircraft stand
- Drivers can also be upskilled to take on larger responsibilities, such as the role of a fleet supervisor to monitor and manage a fleet of autonomous vehicles from a remote work-station
- Automation will also support operations during inclement weather, contributing to the resilience of Changi's airside operations



2018

Changi Airport started testing autonomous solutions at the airside; the technology was determined to be not ready for implementation

2020/2021

COVID-19: With advancements made in AV technology as well as taking advantage of the reduced air traffic volumes, Changi Airport restarted its Autonomous Vehicle trials

TODAY

There are now six autonomous vehicles on trial at Changi Airport

## THE CHANGI AV DEVELOPMENT JOURNEY

### VIRTUAL SIMULATIONS

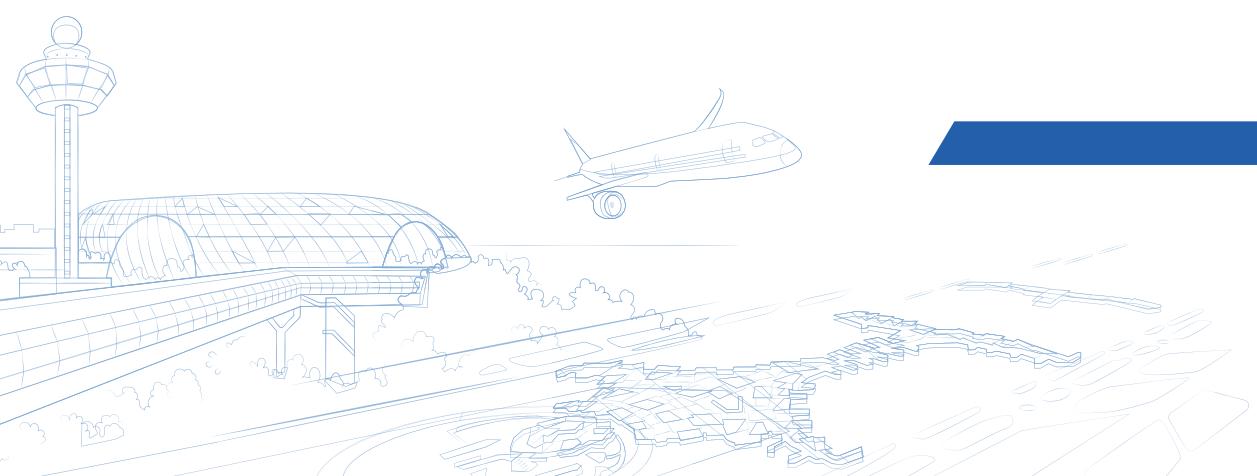
To prepare for the introduction of autonomous vehicles into the airside environment, the Civil Aviation Authority of Singapore took guidance from the Centre of Excellence for Testing & Research of Autonomous Vehicles NTU (CETRAN) framework. CAAS also worked with TNO, an independent research organisation in the Netherlands, to identify 19 scenarios to test the vehicles' ability to manoeuvre.



Overview of the safety assessment framework for autonomous vehicles established by CETRAN

### SAFETY TESTS PRIOR TO ENTERING THE AIRSIDE

Once the Autonomous Vehicles could demonstrate their ability to perform and manoeuvre safely within the 19 scenarios, the next step was to put the actual vehicles through a comprehensive series of tests before they were issued with Airside Vehicle Permits to operate within the airside.



# TRANSFORMING AIRSIDE CONNECTIVITY THROUGH 5G

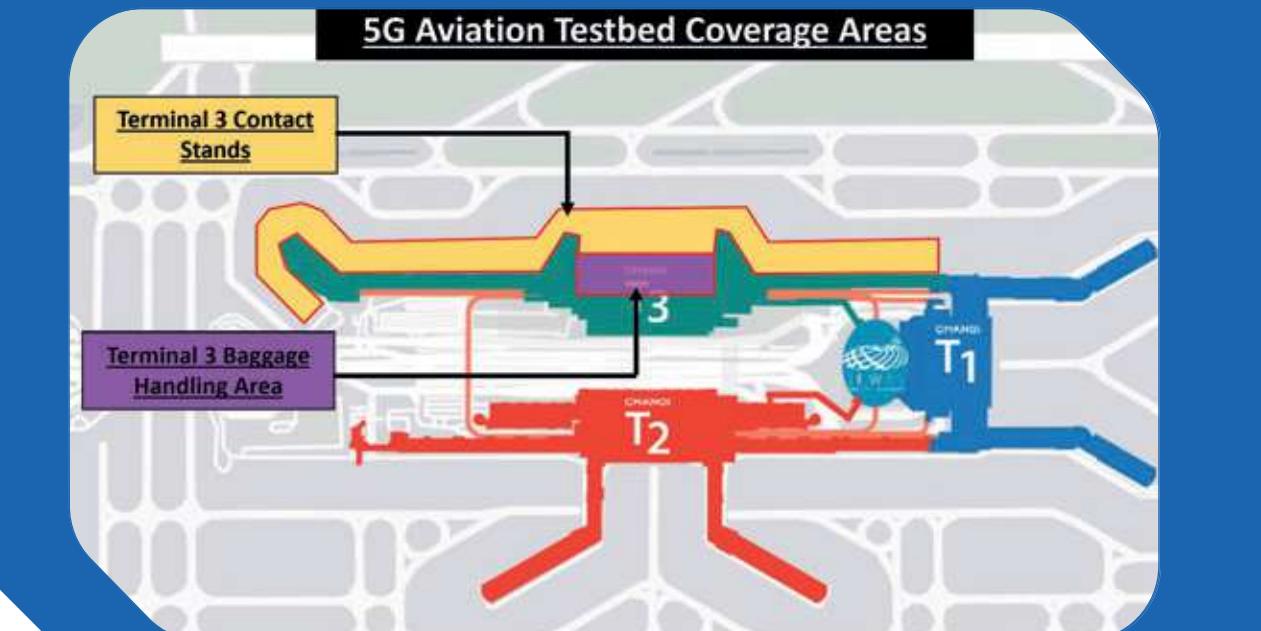
# TRANSFORMING AIRPORT OPERATIONS

## 5G Aviation Testbed @ Terminal 3 Airside

To catalyse the development of innovative use cases to enhance productivity of airport airside operations, the Civil Aviation Authority of Singapore (CAAS) and Singtel, with support from the Changi Airport Group (CAG), launched a two-year 5G Aviation Testbed at Terminal 3 airside from March 2023.

Under the testbed, 5G network infrastructure has been deployed to provide coverage at the Terminal 3 Apron and Baggage Handling Area.

Close to 4,000 Singtel 4G corporate mobile user lines at the airside from the various stakeholders were also given upgrades to 5G lines to facilitate such use cases and connectivity of aviation workers on the airside.



## AVIATION USE CASES FOR 5G

5G unlocks many different use cases such as the use of video analytics and artificial intelligence to predict and drive on-time performance, and ensure optimal resource allocation. Two use cases have already tapped on the 5G Aviation Testbed:

### 1 Secure ground transfer of critical flight data between aircraft and its data centres

Singapore Airlines (SIA) currently relies on a WiFi-based system to transfer data to the aircraft when the aircraft is docked at aircraft stands.

By tapping on the 5G Aviation Testbed, SIA can utilise 5G wireless data transmission without the need for extensive cabling and aircraft modification, enhancing the connection speed and allowing SIA to cut down on the long implementation lead time.



SIA Aircraft docked at aircraft stand

### 2 Remote Supervision of Autonomous Vehicles via Tele-operations

5G is an important enabler that unlocks the ability to trial procedures and systems for remote tele-operations of Autonomous Vehicles. It allows the continuous monitoring of autonomous vehicle operations in real-time at a remote location using high-definition video streams with low latency and high transmission stability.

This enhances the situational awareness of operators, allowing them to supervise AV operations remotely, and carry out actions for safe operations of the vehicle.



5G-enabled remote tele-operation of autonomous vehicle

## ABOUT 5G

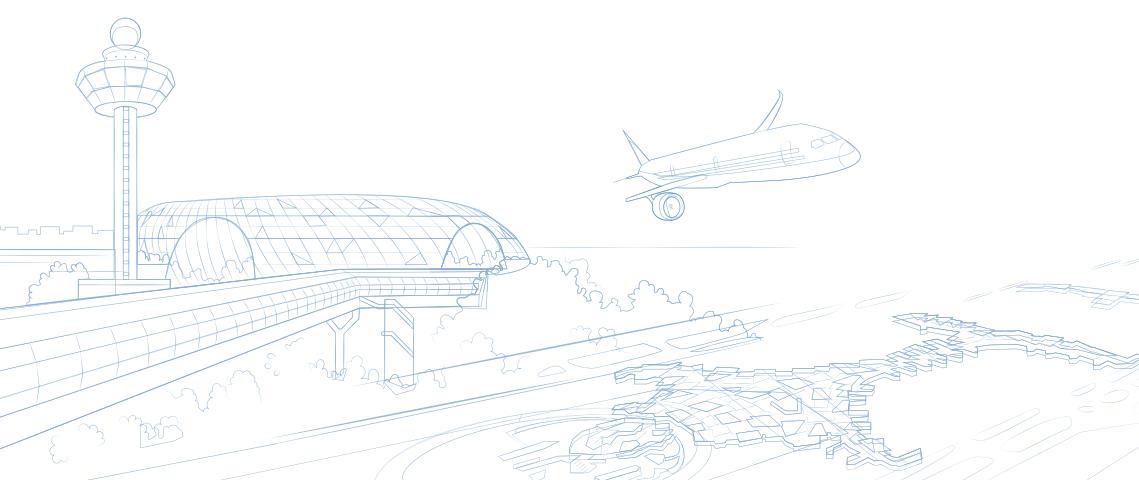
5G provides high connectivity speed, ultra-low latency and high bandwidth, and has potential to enable airport stakeholders to trial and adopt new innovative solutions.

	SPEED	LATENCY	CONNECTIONS	MOBILITY	NETWORK ARCHITECTURE
5G	10 Gbps Per Connection	<3ms E2E Latency	1mil Connections per km <sup>2</sup>	500km/h High speed railway	Slicing Ability
4G	100Mbps - 1Gbps	30-50ms	100x	1.5x	Virtualized Network

## FLIGHT SAFETY

While 5G can unlock new possibilities for airport operations, the safety of flight operations remains a key priority.

CAAS has, in consultation with the Infocomm Media Development Authority (IMDA), engaged CAG and local telecommunications companies in developing safety guidelines and mitigation measures to enhance safety in flight operations, such as restrictions on transmission power and down-tilting of 5G base stations' antennae.



## AUTOMATING THE DRIVING OF TRACTORS AT CHANGI

TractEasy (TEZ) is a collaboration between Easymile, which specialises in autonomous vehicle technology and TLD, a leading manufacturer of aviation Ground Support Equipment.

The vehicle is equipped with a suite of sensors that allows it to travel autonomously along a pre-mapped route and detect obstacles along its path.

The TEZ commenced proof of technology trials in October 2020 to determine its ability to integrate into Changi's environment.

### DID YOU KNOW?

The TEZ has transported more than 100,000 bags between July 2021 to June 2022!

## KEY MILESTONES

Oct 2020	Jun 2021	Sep 2021	Jan 2022	Jun 2022	Present - Nov 2023	Early 2024
Proof of technology & concept	Commencement of Phase 1 trials	1 TEZ operating on flights	2 TEZs operating on flights	End of phase 1 trials	Continued trials & development of tele-operations and fleet management system	Target deployment of small fleet to support ground handling operations
					<b>WE'RE HERE!</b>	



# TRANSFORMING AIRPORT OPERATIONS

## BAGGAGE HANDLING TRANSFORMATION

### GLOBALLY, THE BAGGAGE HANDLING PROCESS HAS REMAINED LARGELY UNCHANGED OVER THE LAST FEW DECADES

The aviation sector has to grapple with similar manpower challenges faced by other industries, including that of an ageing workforce. Baggage handling is also labour-intensive, and there is risk of injury with the handling of heavy baggage.

#### PROCESS FLOW

After baggage is tagged and dropped off at the check-in counters, the bags enter a sortation system before being sent to the baggage carousel assigned to the flight

Baggage handlers would then need to load the bags into carts or trailers for transfer to the aircraft

Upon arrival at the aircraft, the baggage handlers would need to load the baggage into the aircraft



This process is repeated in reverse for arrival flights



### INITIATIVES IN THE WORKS

At Changi Airport, we are trialling new technologies, concepts and equipment, so as to enhance efficiency, drive manpower productivity and improve the working environment for baggage handling staff

#### POWER STOW ROLLERTRACK

**Ground support equipment which is more ergonomically friendly**

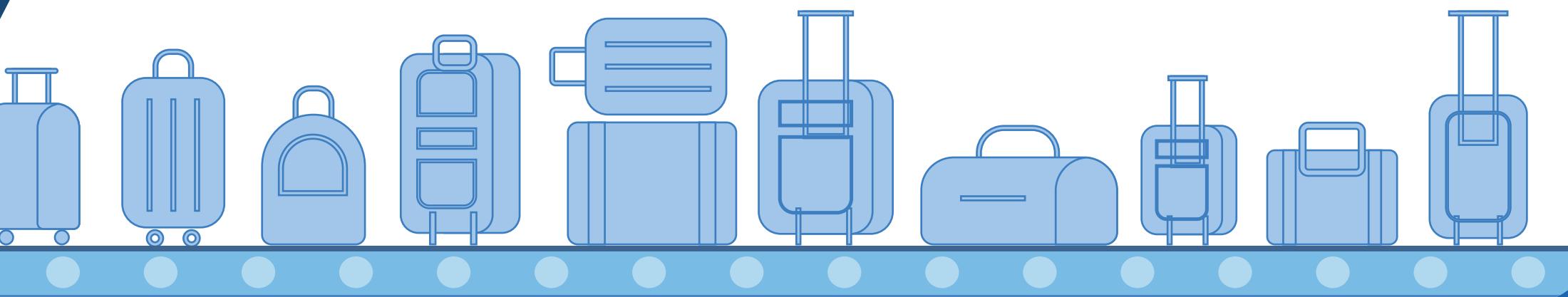
- Changi Airport's ground handlers, SATS and dnata, are trialling the equipment
- Belt loader with extendable snake-like roller belt
- Ability to extend far into aircraft's bellyhold, assisting staff to move bags to aircraft's door
- Staff no longer need to form human chain to carry bags
- Reduces fatigue and manpower needed for task



#### BULK BAGGAGE HANDLING SYSTEM (BBHS)

**A new innovative concept that could transform baggage loading and unloading**

- An innovative concept and system invented in Denmark
- Undergoing trial in Changi Airport
- A semi-automated baggage handling system which utilises specially designed baggage carts and receiver station
- Removes most of the repetitive baggage lifting activities
- Reduces fatigue and increases efficiency and in turn, reduces overall manpower requirements for baggage handling



# TRANSFORMING AIRPORT OPERATIONS

## BBHS: REDEFINING ARRIVAL BAGGAGE HANDLING

### BENEFITS:



**Productivity**  
Estimated manpower savings of up to 25%



**Efficiency**  
Reduction in baggage delivery time

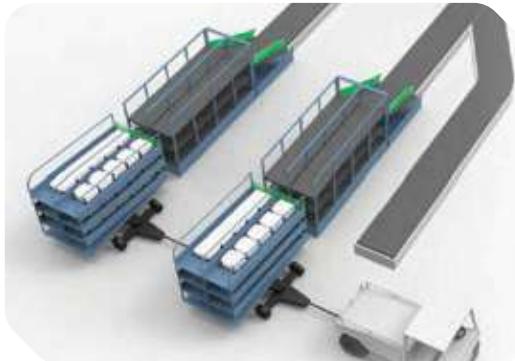


**Job nature**  
95% reduced manual baggage handling



**Workplace Safety**  
Workplace injuries minimized

### MORE ABOUT THE INNOVATION



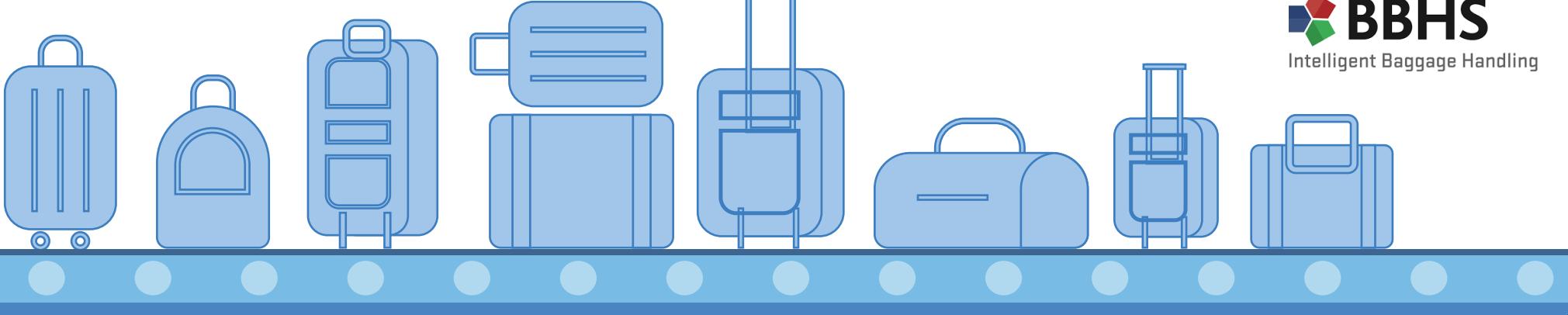
Visual representation of baggage being deposited from the BBHS tiered carts into the Arrival Receiver Station

The “Bulk Baggage Handling System” (BBHS) was brought into Changi Airport for trials in 2019. The concept leverages gravity, and ergonomically designed baggage carts and equipment to assist baggage handlers.

### HOW IT WORKS

- Baggage from arriving aircraft is loaded onto ergonomically designed tiered baggage carts using a conveyor belt known as a belt loader
- Baggage staff do not need to lift the baggage and stack them. Instead, they operate the belt loader controls to feed the baggage directly into the carts
- At the Baggage Handling Area, the process of baggage unloading is done at the touch of a button. With the help of gravity, bags from the tiered carts slide down into the Receiver Station
- Human intervention is only needed to manoeuvre the baggage carts into position and to operate the controls at the last mile

### EXISTING PROCESS



 **BBHS**  
Intelligent Baggage Handling