

Factsheet on the Second Aviation Challenge

The Aviation Challenge was launched in 2014 with the objective of developing innovative solutions to automate labour-intensive processes in airport operations.¹

For the second Aviation Challenge, the Civil Aviation Authority of Singapore (CAAS) sought to improve productivity and reduce strain of cargo handling on workers, caused by the manual stacking and unstacking of cargo, by automating the build-up and breakdown of cargo pallets and containers.

In close consultation with industry stakeholders, the two shortlisted teams started developing their prototypes for this second Aviation Challenge in September 2015. The teams are:

1. Singapore Technologies Dynamics Pte Ltd (ST Dynamics), in partnership with Israel Aerospace Industries Ltd (IAI); and
2. TUM CREATE Ltd Singapore (TUMCREATE).

Each team's prototype comprised three main subsystems:

1. Advanced Cargo Scanning System. The scanning systems are capable of detecting cargo of various sizes, shapes and materials, and can also identify various handling labels such as 'fragile' and 'dangerous goods'.
2. Intelligent Optimisation Software. The optimisation software processes the cargo data captured by the scanning systems, and plans the build-up and breakdown of the pallets and containers. The optimisation software is currently programmed to maximise the volume, weight and stability of the cargo pallet and container, but can also be programmed for other parameters.

¹ 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.

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3. Automated Robotic System. The robotic system comprises robotic arms with specially designed grippers to pick and place a wide range of cargo with high precision, and can work alongside Automatic Guided Vehicles.

Through November 2017, the developed prototypes were assessed by an evaluation panel comprising key members of the air cargo and logistics community – CAAS, DHL Global Forwarding (S) Pte Ltd, dnata Singapore Pte Ltd, SATS Ltd, Singapore Air Cargo Agents Association @Singapore, Singapore Airlines Cargo Ltd, and Singapore Logistics Association.

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

ST Dynamics-IAI Solution

About ST Dynamics and IAI

ST Dynamics is the Advanced Engineering Centre for ST Engineering, which spearheads the development of a broad portfolio of future technologies and capabilities for ST Engineering. As a system house which develops advanced engineering systems, ST Dynamics helps customers address their complex technical challenges in areas of unmanned systems, machine vision, sensors network and software algorithms. ST Dynamics is also an incubator for new technologies and emergent business concepts for ST Engineering. Over the years, ST Dynamics has developed capabilities in systems engineering, processing algorithms for videos, images and sensors, and the deployment of wireless sensor networks.

For this second Aviation Challenge, ST Dynamics worked with partner, Israel Aerospace Industries Ltd (IAI), to develop an automated solution for cargo handling operations.

IAI is Israel's largest aerospace and Defense Company and a globally recognised technology and innovation leader, specialising in developing and manufacturing advanced, state-of-the-art systems for air, space, sea, land, cyber and homeland security. Since 1953, the company has provided advanced technology solutions to government and commercial customers worldwide including: satellites, missiles, weapon systems and munitions, unmanned and robotic systems, radars, C4ISR and more. IAI also designs and manufactures business jets and aerostructures, performs overhaul and maintenance on commercial aircraft and converts passenger aircraft to refueling and cargo configurations.

About the ST Dynamics-IAI Solution

The team's solution is designed to be cost-effective and can be easily installed with minimal modifications to existing cargo terminal infrastructure.

The solution maximises the volumetric utilisation of cargo Unit Load Device (ULD) pallets and containers. It offers the following capabilities:

i. Automatic cargo scanning and logging via 3D scanning systems

- Upon cargo arrival, the scanning station creates a 3D analysis of its shape and weight, and records any special handling instructions or rules.

ii. Automatic storage, retrieval and transport of cargo items using Automated Guided Vehicle Forklifts (AGVs)

- AGVs pick up cargo items from the scanning station and store the cargo at an assigned storage area. The AGVs automatically adjust their fork width, so that wooden skids and crates of different widths can be handled without human intervention. Once the ULD build-up process starts, the AGVs retrieve cargo items from the storage area and place them at the cargo build-up area. The AGVs then assist in the build-up of ULD pallets for large and heavy cargo items on wooden skids.

iii. Advanced ULD Planning Optimisation Software ensuring the automatic building of ULD Pallets with high volume utilisation

- High ULD volume utilisation is achieved through optimisation software and ULD scanners. The software generates the optimal ULD build-up plan and instructs the AGVs and robotic arms on the loading sequence and where best to place the cargo items on the ULD. ULD scanners also provide real-time feedback on available space. All these steps are performed in real time while taking into consideration operational rules and loading constraints.



iv. Robotic arms accurately placing cargo items on ULD pallets and inside containers; and custom designed robotic end-effectors safely picking up and accurately placing each cargo item

- A fleet and resource management system controls multiple robotic arms and AGVs, enabling simultaneous build-up of multiple ULDs using the same robotic arms and AGVs.

v. Semi-automatic pallet breakdown



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TUMCREATE Solution

About TUMCREATE

TUMCREATE is a research platform for the improvement of Singapore's public transportation, including the deployment of electric and autonomous mobility. Researchers from Technical University Munich and Nanyang Technological University join forces and are funded by Singapore's National Research Foundation as part of the Campus for Research Excellence And Technological Enterprise (CREATE).

TUMCREATE is made up of over 100 scientists, researchers and engineers led by Professors from the Technical University of Munich and Nanyang Technological University.

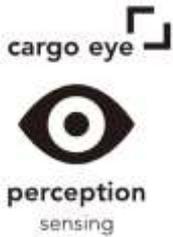
About the TUMCREATE Solution

TUMCREATE developed SPEEDCARGO, the world's first artificial intelligence (AI) powered robotic system which automates the build-up and breakdown of air cargo pallets.

SPEEDCARGO addresses the non-standardised cargo shipment category and can handle a wide range of cargo shapes, dimensions, materials and weight. Palletisation of such cargo is a labour-intensive process and is performed manually worldwide. Deployment of SPEEDCARGO increases productivity, work safety, security and upgrades job profiles within the aviation cargo industry.



SPEEDCARGO is a turnkey solution realised using the vital ingredients which define intelligent systems: perception (sensing), cognition (planning) and action (manipulation). It consists of 3 subsystems – CARGO EYE, CARGO MIND and CARGO ARM.



CARGO EYE produces a detailed and accurate digital fingerprint of incoming cargo in real-time, using the most advanced 3D camera system for three-dimensional acquisition of geometry and image. It goes beyond state of the art by capturing non-standardised labels and material information of the cargo in addition to its dimensions, weight and centre of mass of a box. The user interface can be handled by a worker after a single day of training. CARGO EYE can be connected to any database or inventory management system for storing the captured information to be used for planning and handling.



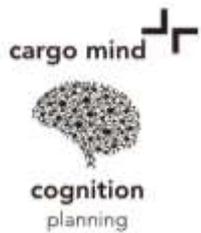
precision upto 5mm

full 3D model for structural analysis

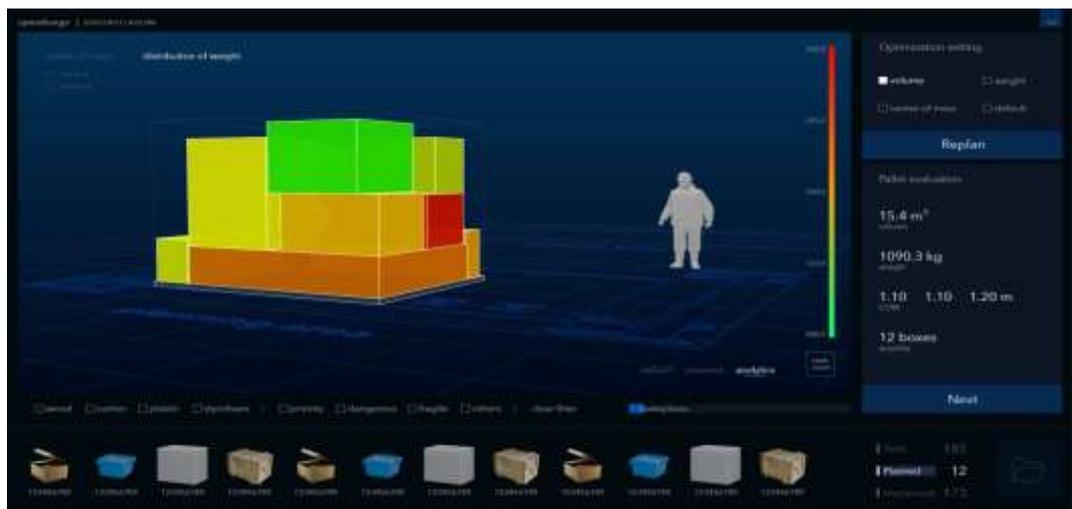
automatic material detection & classification

automatic label detection & classification

modular installation



CARGO MIND forms the core intelligence of SPEEDCARGO. It is an artificial-intelligence-based software solution that guarantees optimal packing results at any given time.



digital twin of the real system

automatic packing optimization

compliance for aviation regulations

robot agnostic motion planning

anytime re-planning

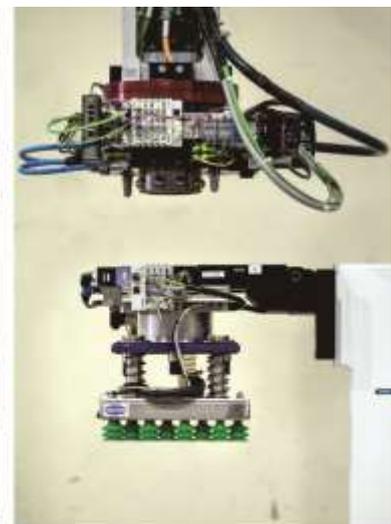
It ensures that all aviation safety regulations for pallet packing are met, while providing the operator a flexible planning tool to maximize profit. In addition the system is able to re-plan a pallet at any given time within the process to accommodate any last minute modifications; for example, a new cargo shipment needs to be accommodated on an existing pallet that has been partially built. CARGO MIND enables the structural build-up of the pallet by planning collision-free motion trajectories for the robot.



CARGO ARM is the actuating system for handling of cargo shipments. It is equipped with a gantry robot with a suite of advanced grippers to safely grasp and manipulate different types of shipments (ranging in dimensions, material and weight). Although the gantry is a large and heavy machine, it has extremely high precision (0.1mm). Equipped with a plethora of sensors, it can measure and record all important parameters while in motion.



suite of advanced grippers with integrated sensors



operation
24x7

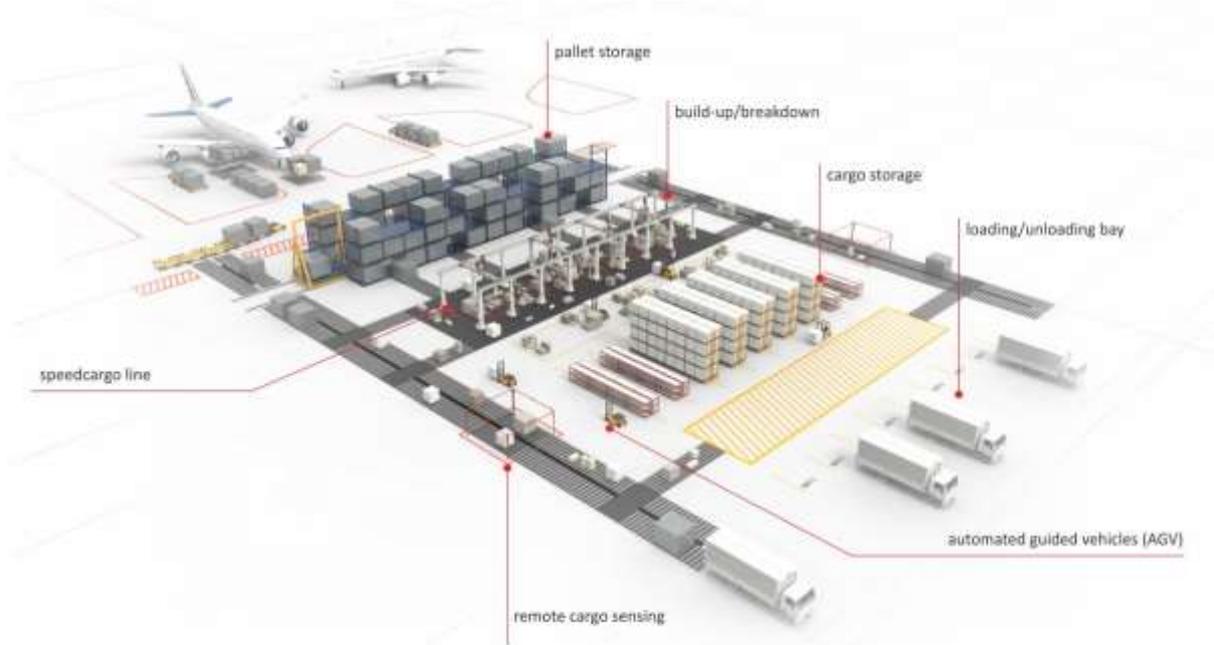
repeatability
0.1mm

high speed
> 2.5m/s

high payload
upto 2 tonnes

safety trigger
< 10ms

Beyond SPEEDCARGO, TUMCREATE's larger vision is to transform the airfreight logistic supply chain with advanced robotics technology and artificial intelligence. TUMCREATE intends to develop an automation roadmap and an ecosystem with a suite of advanced software and intelligent machines to improve yield, efficiency, reliability and security of the entire airfreight logistics process chain.



speedcargo vision - aircargo terminal of the future

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