Robotic Baggage Handling

An Integrated Robotic System that places regular random Luggage into ULD Containers and Transport Carts

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Exhibit 1: Baggage loading Cell

ABSTRACT

For the past several decades now, baggage-handling systems at major airports have successfully deployed automated conveyor systems and intelligent sorter technologies. Nevertheless, the most difficult operation in the entire baggage handling process is still performed manually, and entails the physical loading of baggage into ULDs and onto transport carts. This operation remains a difficult and extremely labor intensive endeavor that is both physically demanding and fraught with numerous disability injuries, as well as high employee turnover.

The baggage loading process works as follows: initially, a laser scanner views each piece of luggage; it measures height, length and width and furthermore it identifies and discriminates precisely what kind of baggage is being presented, such as whether it is a hard side suitcase, soft bag, rucksack, golf bag, carton case, or any other special configuration. A mechanical end stop is positioned on the conveyor according to the size of the piece of luggage for a centered grip. The data from the sensor system also is given to an intelligent packing pattern generator which calculates dynamically the best position in the container or on a cart for the piece of luggage to be placed as next in order to achieve the highest loading density.

Exhibit 2: The baggage loading process
## INTRODUCTION

With an automated baggage loading process (please refer to Exhibit 1), passenger baggage profiling can be upgraded to a very high efficiency. All luggage data is available in the cell or robot controller, and has the capability of being accessed from any location. The position of each piece of luggage in a container or on a cart can be saved, graphically visualized, and printed on a smart chip (RFID), which can be attached to the security transport strapping on the luggage. This technological advancement will shorten the inordinate number of delays in departures, and also serve to dramatically increase overall security. Moreover, and most importantly from an overall security perspective, this is the least secure aspect of the entire baggage handling system due to the number of human beings involved in the handling of baggage during this segment of the process. Automation of this segment, coupled with the incorporation of explosive detection devices into an overall integrated robotic system, will go a long way toward achieving safe and secure baggage handling operations, while at the same time contributing toward the restoration of passenger confidence in the overall safety of air travel. This newly developed system utilizes technology that has been jointly developed for the warehouse distribution industry. It can also be applied to upgrading existing airport baggage handling and logistics systems.

KUKA first began its research and development efforts on automated stacking processes in 1997. These early efforts focused on two separate but very similar robotic applications: (1) baggage loading; and, (2) order picking / mixed palletizing in distribution warehouses for groceries (Please refer to Exhibit 3).

## CELL CONFIGURATION

### 2.1 Robot Technology

One of the basic components of the baggage loading cell is a standard KUKA robot (KR) with a PC-based robot controller (KRC2) along with the KUKA control panel (VGA, 256 colors). Please refer to Exhibit 4.

![Exhibit 4: KUKA Robot (KR), Controller (KRC2), and Control Panel (KCP)](image)

The robot control software essentially consists of three major components or elements as listed below:

- “VxWorks” from company WindRiver Systems, Inc. as the real time operating system
- “MS Windows” from Microsoft for interfacing with the operator
- The KUKA robot language (KRL) for controlling the robot

KUKA utilizes standardized off-the-shelf robotic accessories, including all types of energy supplies, power conditioning and control systems, safety features, fieldbus interfaces, linear units, etc. Moreover, with a software tool called “PC-Duo”, KUKA robotic baggage handling systems can be easily connected to any kind of SCADA system for real time system monitoring, data acquisition, and tamper free reporting. Due to the PC-based controller, we were capable of adapting and transferring all recent developments from the PC-office world to the industrial world. For example, KUKA offers its customers a web-based remote diagnostic for preventive maintenance whereby each robot gets its own homepage.

### 2.2 Gripper Technology

A breakthrough component of the baggage loading system is the gripper technology that...
has been deployed to handle virtually all pieces of baggage, regardless of size and composition. Various survey on airports were done. (For example refer to Exhibit 5). All results of these surveys demonstrated that there are no standard types of baggage, there are no standard sizes, or standard weights.

Due to these experiences it became clear that the gripper principle had to be extremely flexible in order to be capable of handling a variety of different types of luggage as well as a wide range of sizes.

This technology is comprised of the following major elements:

- A standard strapping machine which is actually used for securing carton cases for transportation.
- A very simple gripper that is essentially a plate that can be adjustable in width based on the size of a particular piece of luggage.

The strap can either be left on the luggage (a micro chip can be fixed at the strap to support the passenger baggage profiling; this also improves the security), or can be cut by a special cutting device that is integrated in the gripper, rolled up, and removed (Please refer to Exhibit 6).

With this gripping mechanism, all types of luggage can be handled with only one tool. The straps are strong enough for baggage weights up to 130 pounds.

The most important externality in the development process was related to the impact of the strapping to the luggage surface. Consideration was given to the strapping tension which had to be high enough to handle all types of luggage in any orientation, yet not damage the surface of the suitcases or bags. To achieve this goal FEM calculations were applied to varying strap tensions, gripper sizes and differing types of baggage (Refer to Exhibit 7).

As a result of these investigations we proved that this gripping principle caused no damage during the handling of the luggage in all orientations and degrees of movement.
2.3 The Sensor System

The information regarding the size of the next piece of luggage comes from a standard industrial laser scanner that is located above the baggage conveyor in front of the strapping machine creating a three-dimensional scan for each piece of luggage. (Refer to Exhibit 8).

Furthermore, there is a wide range of additional information that we obtain by scanning the luggage. For example the system is capable of recognizing wheels and handles. Therefore it can automatically distinguish between the different types of baggage. This information is important to enhance the overall process: For example when a trolley is handled by the robot it ensures that the handle can not slide out and cause collisions.

2.4 The Loading Algorithm (LOGO)

As soon as a piece of luggage arrives on a conveyor to the strapping machine, the robot moves the gripper plate to the position where the piece of luggage and the gripper can be strapped together. In parallel, the loading algorithm program (LOGO) determines the optimum position for the piece of luggage to be placed in the container or on the cart. This calculation is comprised of the size of a single piece of luggage and the current packing pattern. (Please refer to Exhibit 9). Moreover, the packing/palletizing algorithm is capable of multiple container loading. As a result, luggage can be apportioned to different ULDs and/or transfer carts by the robotic system based on given parameters such as class of service (1st class, business class, or economy class) and also destination. This algorithm calculates the position of each piece of luggage with respect to both high load density and load stability.

3 SUMMARY

The cycle time for this baggage loading system will be at the most 12 seconds per piece of luggage. In an optimized process, it is estimated that the turnover will be somewhere between 300 and 400 pieces per hour for each installed robot. Moreover, the KUKA baggage loading system requires only a very small footprint, and is well suited for fast track retrofitting of existing logistic systems found in most major airports today. In addition, with the incorporation of explosive detection devices the automatic baggage loading system should go a long way toward simultaneously alleviating baggage security problems at major airports and also restoring public confidence in air transportation systems from the standpoint of the flying public.

REFERENCES


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