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Smart Baggage Services 4.0 – Concept for integrated baggage logistics services based on a Digital Twin

Dipl.-Ing. Andreas Quick [1]

[1]*Fraunhofer-Institute for Material Flow and Logistics IML, Department of Aviation Logistics, Frankfurt/Main Airport, Germany*

Abstract. Baggage services are carried out by various independent companies negotiating ad hoc transactions and activities. Low status transparency of a piece of baggage leads to mishandling and additional costs. Although more comfortable traveling is increasingly appreciated passenger accompanied baggage transportation is still standard. In industrial practice the implementation of economically door-to-door business models is difficult. One reason for that is a lack of data integration and data analysis concepts. Against this background the possibilities have to be exploited given by increasing digitization of passengers and baggage. "Smart Baggage Services 4.0" describes the concept of an integrated baggage logistics door-to-door-service that is based on a Digital Twin. The concept for SBS 4.0 corresponds to a 4-layer IT architecture. The Digital Twin essentially consists of defined conversion standards and a data bank description (layer 2). It captures selected raw data of cyber-physical systems throughout the supply chain and lifetime-cycle of the baggage (layer 1). Standardized analysis algorithms (layer 3) provide added-value information including context-specific monitoring characteristic curves and key figures (layer 4). The Digital Twin is an enabler for developing new generation of autonomous and predictive assistance tools for airports, airlines and passengers to control and monitor end-to-end baggage flow in an interactive way.

1 Initial situation and need for research

More than 220 million arriving or departing passengers per year in Germany [1] are self-responsible for the transportation of their baggage in the pre- and post-haulage phase of travelling. An integrated, individualized and transparent transport of baggage is not offered to the passenger by the actors of the baggage supply chain yet. Instead passenger accompanied baggage transportation is still standard. The demographic change is fact and the full inclusion of people with disabilities plays an increasingly important role in society. Therefore journey's that do not require excellent physical capability and can be easily accomplished are preferred by elderly and disabled people. Furthermore comfortable traveling is increasingly appreciated by other groups such as business travellers and families, too.

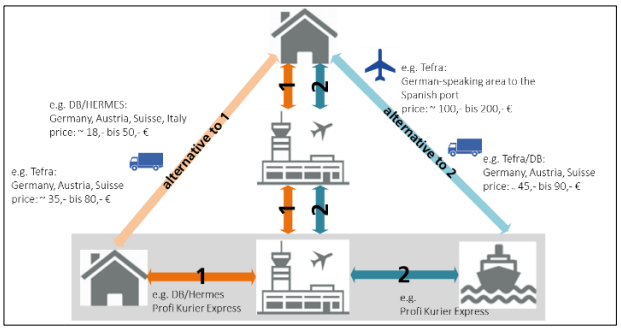

Figure 1. Up-to-date baggage services in the pre- and post-haulage phase in Germany.

Today business models of actors along the baggage supply chain are not adequately adjusted to meet these needs. Baggage services are characterized by a very high extend of labour division between various legally independent companies negotiating ad hoc transactions and activities based on highly complex relationships. In order to cope with process and decision complexity as well as with speed

requirements isolated IT solutions are partially used along the baggage supply chain. The sporadic identification of baggage is carried out using temporary paper labels with barcodes as part of a single journey. As a consequence baggage has no fixed ID or self-intelligence.

In this environment, both national and especially international travels lead to a number of organizational and technological challenges for German companies along the baggage supply chain. Because of low position transparency of a piece of baggage in combination with the relatively low reading quality of today's barcodes with less than 95% [2] it leads to baggage mishandling (especially for transit passengers) additional mishandling costs and a limited travel comfort for passengers. Valid studies show that global cost savings are estimated to be around US $ 3 billion over the next 7 years by using RFID instead of barcodes for international end-to-end baggage tracking [3].

Therefore, sustainable business models and promising employment perspectives along the baggage supply chain can only be achieved by establishing intermodal end-to-end transport processes, new cooperation models between various legally independent actors, an improved decision making and supporting trends deriving from Industry 4.0. However, the implementation of viable and economically sustainable business models is difficult in industrial practice. One main reason for that is a lack of profound data integration and data analysis concepts along the baggage supply chain.

2 Primary objective and approach

Against this background the possibilities have to be exploited given by the increasing digitization of passengers as well as baggage. Therefore, "Smart Baggage Services 4.0" describes the concept of an integrated baggage logistics door-to-door-service that is based on a digital twin.

Figure 2. New baggage technology (Rimowa, Delsey, Samsonite, Lufthansa, Quantas, Globatrac, FastTrack, BAGTAG).

The digital twin captures the collected raw data throughout the entire baggage supply chain and lifetime-cycle of the baggage. It enables a reliable identification of a piece of baggage due to its unique characteristics ("Footprint") that are completely stored within the digital twin. An open and standardized construction kit has to be developed. It essentially consists of defined conversion standards and a data bank description for the digital twin of the baggage as well as standardized analysis algorithms. That allows data analysis as well as direct and predictive process intervention at any time. Real and virtual baggage transport merge into an intelligent overall system.

After all the digital twin is an enabler for developing new generation of autonomous and predictive assistance tools for airports, airlines and passengers to control and monitor end-to-end baggage flow in an interactive way. New innovative business models based on autonomous end-to-end baggage processes can be developed for actors of the baggage supply chain. Baggage will be transported from start to endpoint independently of the passenger in the future.

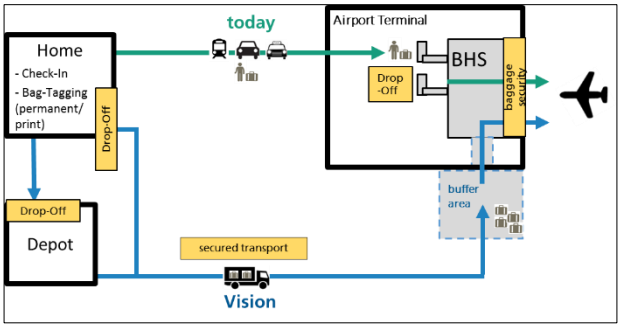

Figure 3. Integrated transport for unaccompanied baggage in pre-haulage phase.

3 Method and solution concept

The technological foundation for SBS 4.0 are cyber-physical systems (CPS) and the Internet of Things (IoT) such as Auto-ID technologies and wearables. The concept for SBS 4.0 corresponds to a 4-layer IT architecture.

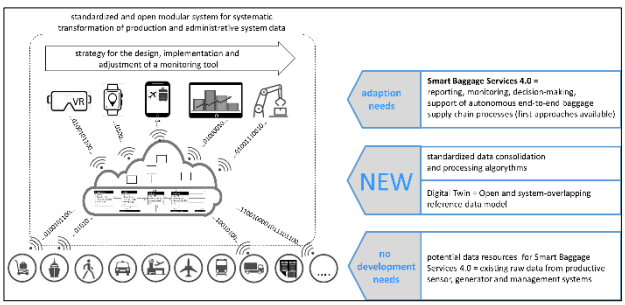

Figure 4. The layer IT architecture of SBS 4.0.

The bottom layer includes the potential raw data, e.g. from existing sensor systems, logistics and business objects with jointly usable metadata in a digital format that can be easily analysed by computers. Selected raw data is uploaded in

predefined cycles into a separate controlling database of the 2nd layer. This database represents a digital twin of the baggage and is described as a database model that works as a standardized, open and cross-system reference database model. The database will contain complete and individual information about the real piece of baggage, such as:

- from the product development phase: e.g. bounding geometry, net-weight, material and texture
- from the production phase: e.g. unique and permanent (production) ID
- from the use phase: e.g. tracking data, gross-weight, baggage content
- from the end of life phase: e.g. date of disposal

A "selection and aggregation layers" has to be built up within the 3rd layer by standardized analysis mechanisms (drill down, drill though), which can be created on a modular basis and can be adapted to individual companies' requirements. The top layer provides the added-value information including, among other things, context-specific monitoring characteristic curves and key figures. This data can be provided to a new generation of autonomous and predictive assistance apps/tools for airports, airlines and passengers via cloud connection.

4 Application potential and exploitation

The market potential of SBS 4.0 is estimated to be very high because of the annual passenger volume. This estimation is based on availability of new technical possibilities by means of industry 4.0 as well as on urgent need of passengers, which has been proved by various trend studies [4]. Started research activities, are focused on selected airport locations with proprietary IT-approaches only. However, "seamless traveling and door-to-door" is not the focus of the ongoing research projects [5].

With its general and superior approach SBS 4.0 will provide a significant added value for passengers in terms of travel time, flexibility, reliability, mishandling rate, comfort and travel costs. Service providers will be enabled to offer individualized, integrated and transparent overall door-to-door baggage transport due to the needs of different passenger types. For the first time interaction between travelers and service providers will be implemented to control the baggage flow before, during and after baggage transport. The prospects for economic success, e.g. for airports and airlines, is regarded as extraordinarily high, too, since it can be assumed that a significant increase in costs and profits is achieved by a more precise image of current events, reduction of redundancy and mishandling rates, improved resource planning, faster throughput times and optimized pay-load and quality. Baggage production companies will get the ability for targeted advertising, sales and maintenance measures based on real baggage usage. Development of operation-optimized products and new business models, e.g. leasing according to operational performance, will come in sight.

Against this background Fraunhofer IML has also repeatedly been asked by various industry partners to exemplarily realize the vision of SBS 4.0 within the scope of a research project and to demonstrate its actual value. The main focus of a research project to be launched by Fraunhofer IML soon will be on the following aspects:

- examination, inventory and requirement engineering
- development of a general concept
- development of a demonstrator
- description and programming a standardised modular database for the digital twin
- description and programming of standardized evaluation algorithm with interfaces to the cloud
- description and programming of exemplary mobile Apps/Tools for actors and passengers
- testing, evaluating and optimizing of the demonstrator

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