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MODELLING OF A CONVEYORS SYSTEM AS A TOOL FOR TESTING OF A BAGGAGE HANDLING PROCESS

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Abstract:

The basic task of air transport is to transfer reliably both passengers and all their baggage to their destinations. Airport systems of baggage handling are of great importance in modern air transport. Failure of these systems often causes a collapse and blocking of the airport. Development of automatic systems of baggage handling is not possible without formation of computer models and subsequent simulation experiments. The baggage handling systems can be modelled as systems of mutually connected conveyors. The conveyor system must comprise a built-in system for scanning baggage identification data and their sorting by destinations. A system of baggage handling modelled as a discrete event system using Witness PwE simulation program is described in the contribution. The results of reliability testing of the system in dependence on different conditions are presented as well.

1. Introduction

According to the Council Directive 96/67/EC [Council Directive, 1996] "groundhandling services are essential to the proper functioning of air transport and make an essential contribution to the efficient use of air transport infrastructure. Baggage handling comprises handling baggage in the sorting area, sorting it, preparing it for departure, loading it on to and unloading it from the devices designed to move it from the aircraft to the sorting area and vice versa, as well as transporting baggage from the sorting area to the reclaim area".

The airport baggage handling and processing systems [VanDerLande, 2010] have strictly speaking three main jobs:

- moving bags from check-in area to a carriage or container in departure area,
- moving bags from arrival gates to the corresponding departure gates during transfers,
- moving bags from arrival gates to carousels in baggage-claim area.

They are described in detail in our previous contribution [Hanta-Poživil, 2008]. The current contribution is more focused on determination of the capacity of a baggage handling process and on identification of causes of the conveyor systems blocking.

2. Modelling of Conveyors as Discrete Event Systems

At present computer models and simulation experiments are successfully used to design, verify and improve production, service and logistic processes [Robinson, 1994]. These methods often lead to higher reliability, reduced costs and increased profit in final result. Conveyors as one of means for material transport modelling present very special field of simulation. For modelling of them the

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Witness simulation software has been used. The Witness PwE simulation program [Peredo, 1998] is a useful and powerful tool for simulation of discrete event systems [Cassandras-Lafortune, 2008]. It has defined two basic types of conveyors – indexed and continuous ones. Each of them has two forms – fixed and queuing. Fixed conveyors maintain a constant distance between transported objects. If the conveyor stops, the distance between the objects on the conveyor remains the same. Queuing conveyors allows transported objects to accumulate. If the conveyor becomes blocked, the parts will slide together until the conveyor is full [Witness, 2008].

- Indexed conveyors whose length is given by the number of parts – objects to be transported and speed by the index time. That is the time in that parts move by one position. Real sizes of parts cannot be modelled using this type. The number of parts and their distances given by the number of intermediate positions are essential.
- Continuous conveyors whose sizes and speed are given in standard physical units. These conveyors enable to model different sizes of parts described by means of system attributes *Length, Width* and *Height*.

Connection of conveyors to each other and with other elements of a model is described by input and output rules. Indexed conveyors have defined two discrete events – input and output of parts. Continuous conveyors enable to place sensors at any position on the conveyor. For sensors additional events can be defined depending on the phase of part passing the sensor. In addition to the front and rear the position of parts on indexed conveyors can be described by indices (integers). For continuous conveyors sensors can be used for positioning of parts (real numbers). Properties of sensors were used for modelling of important functions of baggage handling process. Conveyors can be visualized by a number of graphics; the most suitable graphic element is *Path* that most of all corresponds with reality.

3. Description of the Baggage Handling Process

The model of a baggage handling process (Fig. 1) describes a simplified baggage handling system: transport from arrival gates, transport from check-in area, baggage identification by means of bar codes, pre-sorting into terminating and transit baggage, sorting of transit baggage according to their destination and transport of terminating baggage to reclaim carousels. This system is modelled using twenty-one mutually connected continuous conveyors.

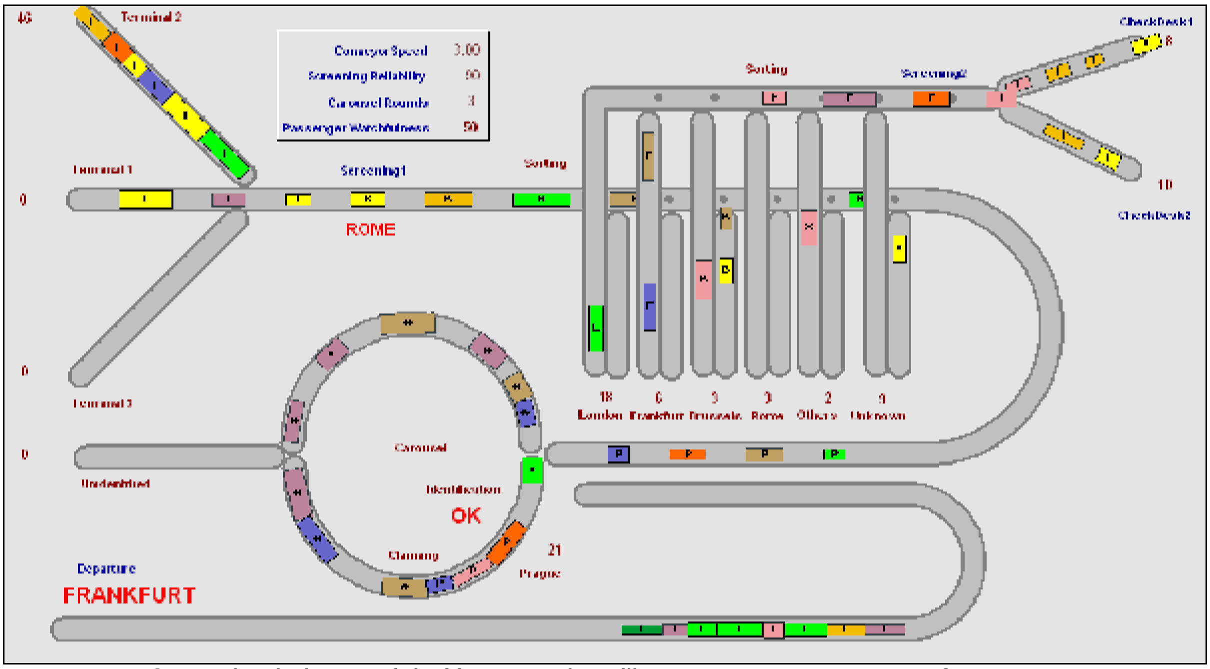

***Fig. 1** Simulation model of baggage handling process as a system of conveyors*

Passengers' baggage enters the airport baggage handling system at more points (check-in desks, collecting conveyors and arrival terminals). Their arrivals are given by different schedules determined by timetables of airline companies and public transport simultaneously with individual transport by passenger own cars and taxis. These schedules show considerable stochastic features already during short-term monitoring. Simultaneous operation of several schedules is successfully solved by use of special simulation elements – part files together with random statistical distributions. Inter arrival times and lot sizes are generated randomly oscillating around given average values.

The baggage movement speed can be the same for all conveyors or each conveyor can have its own speed of baggage movement. Baggage is transferred from three terminals to the central conveyor according to the schedule specified in advance. The schedule can be deterministic (according to timetables), stochastic (according to long-term data) or mixed (using timetables with random data). For experiments with arrivals two schedules of baggage arrival are used. In the first schedule baggage enters the model at 1 piece per 3 seconds in the batch of 1000 pieces. They are randomly directed to one of three terminals in the ratio 2:1:1. The second model of schedules uses arrivals according given timetable at every hour between 9 a.m. and 9 p.m.

Baggage on the central conveyor goes through bar code automatic scanning system. Bar codes are read with optional probability of correct reading. This value depends on used system of bar code reading (simple laser scanners about 65 %, camera systems with reconstruction of bar code up to 90 %, RFID scanners more than 90 %). Transit baggage are sorted and moved into separated storages according to their destinations. Transit storages for five destinations (London, Frankfurt, Brussels, Rome and Other – special and rare destinations) are used in the model.

Unidentified baggage with unknown bar codes or baggage with special destinations is moved into a special storage where they must be handled manually. Terminating baggage (destination Prague) continue to the reclaim carousel where bags are to be collected by passengers. There are used two variable parameters in the model: the average value of passenger attention and the maximum number of baggage rounds on the carousel. The baggage uncollected from the carousel is moved after reaching the maximum number of rounds into another special storage.

4. Simulation Experiments with the Model

In the previous contribution [Hanta-Poživil, 2008] a number of simulation experiments were carried out with an imperfect model of the part of baggage handling process. The influence of successfulness of baggage bar code reading, passenger attention to identification of their baggage and the baggage rounds on the carousel were examined. In this contribution a series of experiments for finding out the optimum speed of conveyors is carried out. It is necessary to find the minimum speed needed for transport of baggage delivered in due time at check-in desks to timely make-up. The baggage must be sorted out and transported in time to its airplanes. The number of baggage remained in storages for all destinations (London, Frankfurt, Brussels and Rome) is chosen as a suitable criterion of optimality. The values of this goal function are penalized with values of the actual conveyor speed with the unit weight. The progress of the optimization process (simulated annealing method) is shown in Fig. 2.

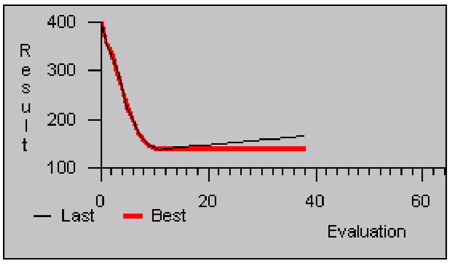

***Fig. 2** Progress of optimization process*

Several chosen values in the neighbourhood of the optimum speed are given in Tab. 1.

***Tab. 1** Neighbourhood of the optimum conveyor speed*

Evaluation	Criterion	Conveyor speed
8	159	10
9	147	11
10	142	12
11	138	13
12	140	14
13	141	15
14	142	16

There is further important task for working with the simulation model – simulation experiment with the aim to determine the capacity of the baggage handling system. It means to find out if ever and under which conditions blocking conveyor system (jam on the conveyor belts) can arise. One possible case is shown in Fig. 3. It results from an analysis of the case that this blocking is caused by simultaneous arrival of a great amount of baggage and insufficient claiming of them from the carousel.

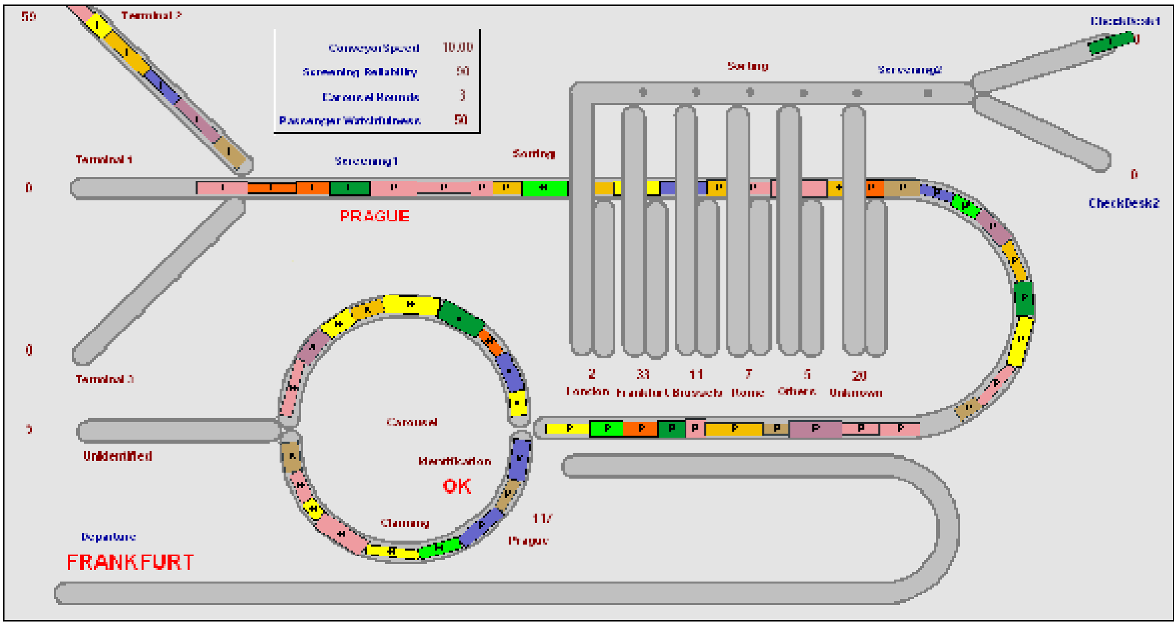

Fig. 3 *Blocking of the conveyor system – a jam on the conveyor belts*

6. Conclusions

The baggage handling system at an airport plays an important role in keeping travellers satisfied. There are described two cases of baggage handling systems at large airports – 1995 Denver [Donaldson, 2002] and 2008 Terminal 5 Heathrow [Thompson, 2008] that had great problems on the day of opening. In both cases enormous losses were created that could have been eliminated if simulation of the designed systems should have carried out with the aim directed to identify bottlenecks and effects of random failures of some subsystems.

In the contribution, a model of baggage handling created in Witness PwE simulation program is described. The model is based on a system of connected conveyors. Simulation approach [Robinson, 1994] has proven to be successful. Experiments with the model show that used method enables to model also more complex airport baggage handling systems. The model can be also used for evaluation of capacity requirements and for testing of planned changes in the system control.

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